THE NEW METHOD OF Fortification,

As Practised by Monsieur *de VAUBAN*, Engineer General of *FRANCE*.

WITH AN

EXPLICATION

Of all TERMS appertaining to that

ART.

Made English.

With CUTS.

The Second Edition.

In which is added, Exact Draughts of *DUNKIRK*, *MAESTRICHT*, *CHARLEROY*, *AETH* and *MATENCE*.

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The Epistle Dedicatory.

To His GRACE, THE DUKE of *ORMOND*.

May it please Your Grace,

THE *General Complaint of the want of Books of* Fortification *in our* English *Tongue, has encouraged me to Translate that of Monsieur* Vauban: *To which I was invited by the almost Universal Applause it has received from the most competent Judges. Nothing could have emboldned me to the Presumption of this Address, but the Good and Welfare of my Native Countrey, by proposing your Grace to the Imitation of*

our Nobility and Gentry, which seems to be the only Means for this Kingdom to recover its Ancient Glory. I doubt not, but that brave Example which your Grace continually sets to the whole Nation, will inspire the Men of Quality to come up to it, as near as possible: Which, if they had always done, Vauban *might, without any great Detriment to us, have been confin'd to the Territories of his Master. That your Grace may ever prosper, and receive the Honours due to so great Merits; as it is the greatest Good can be wished you, so it is no less the unfeigned Desire of,*

May it please your Grace,

Your Grace's most Obedient and most humble Servant,

ABEL SWALL.

THE

THE PREFACE.

THis little Tract, which was chiefly design'd by the Ingenious Author, for the Use and Benefit of young Gentlemen and others, addicted to the Study of this part of the *Mathematicks*, who have not leisure, or opportunity to read over the vast Systems of Voluminous Writers, has deservedly obtain'd so great a Repute among the Curious, that it is Translated into several Languages. It contains an exact Explication of all the Terms that are attributed to Mathematical Bodies; and, in general, all that is necessary for the Theory and Practice of a good *Geometrician*. Moreover, therein is exhibited the true Mensuration of *Heights*, *Lengths*, *Planes*, *Solids*, and *Concaves*; as also, the Science call'd *The Transmutation of Bodies*; which is the Subject of the first Part. In the Second, are explain'd the Rules that are observ'd by the *French Engineers* at this day, in raising their Works; and at the same time, are produced

the different Sentiments of the *French* among themſelves, as to this Matter; it is likewiſe ſhewn wherein their manner of Operation differs from that of the *Germans*, and other Nations. Laſtly, The moſt clear and accurate Method of *Fortification* is plainly taught.

The Word *Geometry*, is derived from the *Greek*, γῆ, & μέτρειν; importing, *to meaſure the Earth*; ſo that *Geometry* (with reſpect to its Etymology,) is nothing elſe but the Art of meaſuring Land; yet in a larger, and more proper Senſe, it is applied to all ſorts of Dimenſions. As for the Original of this Science, it is indeed very uncertain; and it is believed by many, that the *Egyptians* were the firſt Inventers thereof: For in regard that the River *Nile* does every Year overflow the Country of *Egypt*; thoſe Inundations which generally overthrew, and confounded all the Land-Marks, oblig'd the Inhabitants to deviſe certain Meaſures, by the means whereof, they might be able to diſtinguiſh, and adjuſt the Limits of their reſpective Grounds from thoſe of their Neighbours, when the Waters were withdrawn: And this Opinion is not altogether to be rejected; eſpecially if we conſider that *Moſes* is generally reputed to have given them the firſt Rudiments of this Art: However ſince there were not very many Men

who applied themſelves to the Study of good Literature in thoſe early Ages of the World: The *Mathematicks*, and *Geometry* in particular, were, as it were, lock'd up within the Breaſt of ſome few Learned and Skilful Artiſts, until the Time of *Thales*, who firſt publickly profeſſed them in *Greece*; nevertheleſs the *Grecians* were not very diligent in promoting and improving theſe Noble Sciences, and only taught them privately; neither was there any one that undertook to ſhew the Uſefulneſs, and Neceſſity of this kind of Learning, until *Euclid* wrote his Elements; which gave occaſion to the Publiſhing of a great Number of excellent Treatiſes on this Subject, that are now extant.

An Advertisement to the *Book-Binder.*

1. CAre must be taken, not to cut the Blank Paper on which the Plates are wrought off; by reason that the Figures must be so placed as to fold out of the Book.

2. There are Eight Figures which must be placed at the End of the Treatise of *Geometry*, immediately after the Table; they are marked thus: *Geom. Pl.* 1, 2, 3, 4, 5, 6, 7, 8.

3. The other Figures belong to the *Fortification*, and are to be placed at the End of the Book, and set in order as they are marked; A, B, C, D, E, F, G, H, I, K, L, M, N, O, P, Q, R, S, T, V, W, X.

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A NEW

A NEW

TREATISE OF Geometry.

BOOK I.

CHAP. I.

AS an Introduction to our Subject, at our first entry, we shall begin with the Definition of Geometry, and the Explication of those Terms that are hereafter to be made use of.

Geometry is a Science which treats of Magnitudes, and it is the principal part of the Mathematicks.

1. Magnitude is a continued Quantity, which consists either in Lines or Angles, in Surfaces or Bodies.

2. A Line is a length without breadth, whoſe Extremities are called Points.

3. A Point is ſomething which cannot be divided.

4. A Line is right, crooked, or mixt: a right Line is that which goes without turnings from one Point to another. A crooked Line is that which goes off from its bounds, by one or more turnings: and a mixt Line is that which is part right, and part crooked.

5. A Surface is length with breadth: whoſe bounds are called Lines.

6. Theſe Lines are either Parallel or Oblique. Parallel Lines are thoſe which are every way equally diſtant from each other. Oblique Lines are thoſe which meeting at a Point make an Angle.

7. It is called a right Angle when one of the Lines is perpendicular upon the other. It is called an Oblique Angle when one of the Lines is not perpendicular upon the other. It is called a right-lined Angle when it is made up of two right Lines. It is called a Curve-lined Angle, when it is made up of two crooked Lines. It is called a mixt Angle when one of the Lines is right, and the other curv'd. It is called an Acute Angle when it is leſs than a right one.

And

And it is called an Obtuſe Angle, when it is greater than a right Angle.

8. A Figure is a Magnitude bounded by one or more Lines and Surfaces, whereof ſome are plain, ſome ſolid.

9. A Circle is a plain Figure bounded by a Circumference, the middle Point whereof is called the Center, from which all right Lines drawn to the Circumference are equal.

10. A Diameter is a right Line, which goes thro' the Center, and touches the Circumference in two Points.

11. A Semi-Circle is the half of an Entire Circle.

12. An Oval is a plain Figure bounded by its own Circumference, within which no Point can be taken from which all right Lines drawn to the Circumference can be equal.

13. A Triangle may be conſidered either with reſpect to its Sides, or its Angles: in reſpect to its Sides, it is either an Equilateral, which has three equal Sides: or an Iſoſceles, which has two Sides only equal: whoſe third is called the Baſe: or a Scalene, which has three unequal ſides: in reſpect of its Angles, it is either right-angled, which has one right Angle: or A-

cute-angled, which has three acute Angles: or Obtuſe-angled, which has one Obtuſe and two Acute Angles. One of the Lines in a right-angled Triangle is called the Baſe: the ſecond the Perpendicular: and the third the Hypothenuſal.

14. A Parallelogram is a Figure which has four Sides, and four Angles: and it is either equilateral which has four equal ſides, or in-equilateral whoſe ſides are unequal.

15. An equilateral Parallelogram has either right-Angles, as a Square or Oblique Angles, as a Rhombus.

16. An in-equilateral Parallelogram has either right-Angles as a rectangled Parallelogram: which is likewiſe called a long-ſquare; or not, and then it is a Rhomboid: every other ſquare Figure is called a Trapezium.

17. A Tetraëdron is a ſolid Figure, or a Body which is bounded by four equal Triangles.

18. A Pyramid, is a Body bounded by ſeveral Triangles, which making one Surface for a Baſe, meet all in one Point.

19. A Priſm is a Body which has two Baſes, equal and parallel each to other.

20. A Parallelepiped is a Body bounded by ſix Parallelograms, whereof the two oppo-

oppoſite ones are always equal and parallel.

21. A Trapezium is a Body bounded by plain Surfaces, which from neither a Priſm, nor a Parallelepiped.

22. A Cone is a Body made by the turning of a right-angled Triangle round a Circle, the angular Point of the right angle being fixed in the Center.

23. A Cylinder is a Body made by the turning of a right-angled Parallelogram round two Circles one at the top, the other at the bottom.

24. A Cube is a Body bounded by ſix Squares.

25. An Octaëdron is a Body bounded by eight equal and equilateral Triangles.

26. A Dodecaëdron is a Body bounded by twelve equal and equilateral Pentagons.

27. An Icoſaëdron is a Body bounded by twenty equal and equilateral Triangles.

28. A Pentaëdral Priſm is a Body bounded by three right-angled Parallelograms, having two equilateral Triangles for its Baſes.

29. A Rhomb is a Body bounded by ſix equilateral Oblique-angled Squares.

30. A Rhomboid is a Body bounded by 4 Oblique-angled Parallelograms, having two Oblique-angled equilateral Squares for their Baſes.

CHAP. II.

To know how Figures are made, the following Problems muſt be examined.

PROBLEMS.

I. *To draw a Line parallel to a given Line.*

MArk upon the given Line any two points A B where you pleaſe, and by them draw two Arches E F, in drawing a right Line by E F you have your Parallel.

II. *From the point G, to draw a parallel to a given Line H I.*

1. Draw an Arch from the point G, which touches the given Line only in K.

2. With the diſtance G K, draw another Arch upon the given Line M N.

3. The Line drawn by G N ſhall be parallel to the given Line H I.

III. *To*

III. *To raiſe Perpendicular on a given Line, from a given point.*

1. Take a diſtance from the given point (what you pleaſe) to the right, as A B.

2. Take the ſame diſtance to the left, as A C.

3. Take B C and draw two Arches which interſect each other at D.

4. Joyn D and A together, and you will have your Perpendicular.

IV. *To raiſe a Perpendicular at the end of a given Line A B.*

1. Draw a Circle to the point B, from the center C, which may be taken at pleaſure.

2. From the point D, where the Circle cuts the given Line, draw a right Line through the Center C, till it touches the Circle on the other ſide, as at E.

3. Joyn E and B together, and you will have your Perpendicular.

V. *From a given point G, to let fall a Perpendicular upon a given Line.*

1. Draw an Arch from the point G, which may cut the given Line in two places, as C D.

2. From C D draw two Arches under the Line which ſhall interſect each other at E.

3. Joyn E and G together, and you will have your Perpendicular G F.

VI. *To divide a given Line into two equal parts.*

1. From the points A B draw two Arches which ſhall interſect above the given Line at C, and below it at D.

2. Joyn C and D together, and you ſhall have your Line cut into two equal parts.

VII. *To divide a Line A B into ſeveral equal parts.*

1. Draw C D a Line at pleaſure, and mark as many parts as the given Line A B ought to have; ſix for Example, upon this Line as C E.

2. Take

2. Take C E and draw two Arches which may interſect in F.

3. Draw all theſe ſix parts in F.

4. Take the given Line A B, and lay it upon the Lines F E and F C, as G H.

5. Joyn G H together, you will have your given Line A B divided into ſix equal parts.

VIII. *To deſcribe an Angle equal to an Angle given.*

1. Let the given Angle be B A C.

2. Draw the Arch A D E.

3. Draw a Line I L, and upon this Line an Arch with the diſtance A D, as F G.

4. Set the diſtance D E upon the Arch F G, as F H.

5. Draw a right Line from the point I to the point H, which will make an Angle equal to the given Angle.

IX. *To divide an Angle into two equal parts.*

1. Let the given Angle be B A C draw the Arch A D E.

2. From the points D E draw two Arches which ſhall interſect each other at F.

3. The Line drawn from F to A will cut the Angle into two equal parts.

X. *To*

X. *To draw a Circle through three given points A B C, or to find the Center of a given Circle, or to finiſh a Circle when there is but one part given.*

1. With the points A B, make two Arches which ſhall interſect at D above, and at E below the given points.

2. Draw a right Line from the point D to G.

3. Do the ſame thing with B C, ſo that they may interſect in F G.

4. Draw another right Line from F to G, and there where this Line interſects the firſt, as for inſtance at G, you will find the Center, by which you may draw the Circle through the three given points.

XI. *To make a Circle two, three, or four times bigger than the given one, &c.*

1. Divide the given Circle into four equal parts A B C D, with the Center mark'd at E.

2. Take the diſtance A B and put it from E upon the Perpendicular, as E F, and with this diſtance draw a Circle, as big again as that given.

3. To make a Circle twice as big, take A F, and put it from E upon the firſt Perpendi-

pendicular, as E G, and the distance E G will be the Semi-diameter of the demanded Circle.

4. To make a Circle thrice as big, put the distance A G upon the same Perpendicular, as E H, and the distance E H will be the Semi-diameter of the demanded Circle. Thus you may enlarge a Circle for ever.

XII. *To make an Oval.*

1. Draw a Line, and thereupon the Circle B A C.

2. From C draw another Circle through B, as C B D.

3. Take care that these two Circles intersect each other, as in E F.

4. From the point of intersection E, draw right lines through B C, which shall touch the two Circles in G H.

5. From the point E, draw an Arch from G to the point H.

6. Keep this distance, and do the same thing from the other point of intersection F, as I K, and so your Oval will be compleat.

XIII. *To draw a Spiral Line.*

1. Upon a straight Line, draw the Arch A B C.

2. Take

2. Take B C, and fixing one point of the Compaſs upon B, draw from the point C another Arch, which ſhall touch the ſame Line in D.

3. Take the firſt Center A, and draw another Arch from D, that ſhall touch the line in E.

4. Return to the point B, and from it as a Center draw from E another Arch to F.

5. Take A as a Center, and draw an Arch from F to G; and ſo on for ever.

XIV. *To divide a Circle into* 360 *equal parts.*

1. Divide a Circle into four equal parts, as A B C D, whoſe Center is E.

2. From A thro' E draw the Arch F G; ſo alſo draw from B the Arch I H, and from C draw the third K L; and at laſt from D draw the laſt Arch M N.

3. Having by theſe Arches divided the Circle into twelve equal parts, afterwards divide every one of theſe twelve into three other equal parts, and then you will have thirty ſix equal parts.

4. Divide afterwards every one of theſe thirty ſix into ten equal parts, and your Circle will be divided into three hundred and ſixty equal parts.

XV. *To*

XV. *To make an Equilateral Triangle.*

Take a given line A B, and from thoſe two points draw two Arches which ſhall interſect at C; from C draw two right lines to A and B; theſe will make an Equilateral Triangle.

XVI. *To make a Triangle equal to a given One.*

1. Let the given Triangle be A B C, draw a line at pleaſure, and mark thereupon the length A B, as D E.

2. Take the diſtance B C, and from the point E draw an Arch.

3. Take the diſtance A C, and from D draw another Arch which ſhall interſect the firſt at F.

4. Joyn F E and F D together, you will have a Triangle equal to the given one A B C.

XVII. *To divide a Triangle into ſeveral equal parts.*

1. Let A B C be the Triangle to be divided into five other Triangles: firſt divide the longeſt ſide B C into five equal parts, ſo that

that the fifth part, marked at D may be joyned to A.

2. Divide the longest of the two other sides into four equal parts, and let one of them marked G be joyned to D.

3. Divide the remaining part DC into three equal parts, and joyn that marked F by a right Line to G.

4. Divide the remainder GC into two equal parts, and joyn that marked E by a right Line with F. So you may have five equal Triangles: *viz.* ABD, ADG, GDF, GFE, and EFC.

XVIII. *To make a Square.*

1. Take the Line AB, and raise a Perpendicular upon B, of the same height as BC.

2. With the same distance make two Arches from A and C which shall intersect at D.

3. Joyn DA, and DC by right Lines: and you will have a Square.

XIX. *To make a Parallelogram.*

1. Draw a long Line AB, and upon B raise a small Perpendicular BC.

2. Take the distance BC and by the point A draw an Arch.

3. Once more take the Line AB, and by the

the Point C make an Arch which ſhall interſect the other at E; joyn E to A and C and you will have this Parallelogram.

XX. *To draw a Pentagon of equal Angles without a Circle.*

1. Draw a long Line A B, and mark upon it the diſtance A C.

2. Raiſe a Perpendicular upon C, equal to A C, as C D.

3. Divide the Line A C into two equal parts, as A E, E C.

4. Set the Point of the Compaſs upon E; and with the other Point draw an Arch from D, which ſhall touch the given Line at F.

5. By the Points A, C, and the diſtance A F, draw two Arches interſecting at G.

6. Take only the diſtance A, C, and by the Points G, A, draw two Arches interſecting each other in I: ſo likewiſe, by the Points G, C, draw two other Arches which ſhall interſect each other in K.

7. Joyn A I, I G, G K, and K C together by right Lines, and you have your Pentagon.

XXI. *To make a right-lined Triangle equal to a Circle given.*

1. Divide the Diameter of A B the given Circle into ſeven equal parts. 2,

2. Raise a Perpendicular upon B three times as long as the Diameter A B, and a seventh part over, as B C.

3. Draw a right Line from C to D the Center of the given Circle, and that gives you the Triangle.

XXII. *To find the circumference of a Circle, having only the Diameter.*

This Problem must be wrought after the same manner as the foregoing one.

XXIII. *To make a Square equal to a given Circle.*

1. Divide the Diameter A B into seven equal parts.

2. Double this Diameter, and add a seventh part of itself to it, as A C.

3. Divide the first Diameter A B into two equal parts, as A D.

4. Divide the Line D C into two equal parts, and taking the middle Point E, draw from D. to C an arch, as D F C.

5. Raise a Perpendicular upon E to touch the Circle in F: this Line E F shall be a side of the required Square: the rest is wrought by the eighteenth Problem.

XXIV.

XXIV. *To make one Square equal to two.*

1. Let one of the given Squares be A B C D, and the other E F G H.

2. Joyn them both, ſo that the ſides B C, F E, may make one right Line C B E.

3. Joyn A to E, and raiſe a Perpendicular upon E of the ſame length, as E K.

4. Keep the ſame length, and from the points K A, make two Arches to interſect in I.

5. Joyn K I and I A, and your Square will be made.

XXV. *To make a Square equal to a Parallelogram.*

Let the given Parallelogram be A B C D.

1. Lengthen the Baſe D C, and add to it the other ſide of the Parallelogram B C, as C E.

2. Divide the diſtance D E. into two equal parts, and from the middle point F draw an Arch, from D towards E.

3. Raiſe a Perpendicular upon C to touch the Arch in G; this will be a ſide of the required Square; ſet it upon the firſt lengthned Line, and you will have another ſide, as C I.

4. Keep the same distance, and from the points G I, make two Arches to intersect in H; joyn I G H, and H I together, and your Square will be made.

XXVI. *To make a Square two, three, or four times greater than it is.*

Let the given Square be A B C D.

1. Lengthen the side A B, and take the distance B D, and set it upon the lengthened side A B, as A E, and it will be a side of a Square double to that given at first.

2. Afterwards observe what was said above in the Eleventh Problem.

XXVII. *To make an Equilateral Right Angled Square equal to an Oblique Angled Parallelogram A B C D.*

1. From the points A B let fall Perpendiculars to the lower Line, as A E, and joyn it afterwards to the Perpendicular B, as B F.

2. And when you have the right angled Parallelogram A E B F, work on by the twenty fifth Problem.

XXVIII. *To make a right Angled Square equal to the Rhomb A B C D.*

1. From the points B C, let fall Perpendiculars upon the Line, and set the distance B E, upon the other point C, as C F.

2. Joyn E F together, and the sides B C E F will make a right angled Square equal to a given Rhomb.

XXIX. *To make an Equilateral Right Angled Square equal to the Triangle A B C.*

1. Lengthen the Base C B, and divide the same Base into two equal parts, as C D, D B.

2. From the point B let fall a Perpendicular equal to B D, as B F.

3. Lengthen B F upwards, and from the point A draw a Parallel to the Base C B, which shall cut the lengthened Line B F in E.

4. Divide the distance F E into two equal parts, and from G the middle point draw an Arch from E to F; and from the point H, where this Arch touches the first lengthened Line C B, to B shall be the first side of the Square, which laid upon the Line B E, will give another side B I; afterwards

from the points I H, make two Arches which shall interfect each other in K; and joyn H K and K I together, and your Square will be made.

XXX. *To make a Parallelogram equal to a given Triangle A B C.*

1. Divide the Base A B into two equal parts, as A D, D B.

2. Divide the side C B into two equal parts, as B E, E C.

3. Draw a right Line from D to E, what length you please, and take the distance D E, and set it from the point E, to lengthen it, as E F.

4. Take D F, and from the point B make an Arch.

5. Take D B, and from F interfect this Arch in G.

6. Joyn F G and G B together, and your Parallelogram will be made.

XXXI. *To make a Parallelogram equal to a right Angled Square A B C D.*

1. Lengthen the side of the Square A B, adding double its own length to it, as B F.

2. Divide the side of the Square B C into two equal parts, as B E, E C.

3. Take

3. Take B F, and from the point E make an Arch.

4. Take B E and interſect this Arch from the point F in G.

5. Afterwards joyn E G and G F together, and you have the Parallelogram required.

XXXII. *To make a right lined Figure equal to a Figure given.*

Let the given Figure be A B C D E.

1. Take any one of the points, which you pleaſe, A for inſtance:

2. From A make as many Triangles as there are oppoſite Angles in the Figures A B C, A C D, A D E.

3. Then take a Line at pleaſure, of the length of A B, as F G.

4. From the point G, with the diſtance B C, make an Arch.

5. With the diſtance A C interſect this Arch, from F in H, and joyn G H together.

6. From the point H, with the diſtance C D make another Arch, and interſect it from F in I, with the diſtance A D, and this muſt be joyned to H.

7. Take A E, and from this point F make the laſt Arch; interſect it from I in K, with

the distance D E, and joyn it with I F: so the Figure F G H I K, will be equal to the given Figure.

CHAP. III.

Of BODIES.

PROBLEMS.

I. *To make an equilateral Tetraëdron.*

1. MAke an equilateral Triangle ABC.
2. Place another equilateral Triangle upon every side, as ABE, BCD, & ACF, and your Tetraëdron is made.

II. *To make a Cube.*

1. Make an equilateral right-angled Square ABCD.
2. Upon every side place another Square equal to the first, as ABEF, BCGH, DCIK, ADLM.
3. Joyn EF, GH, IK, and LM together by right Lines.
4. Place another Square equal to the rest upon one of these four, as KINO, and the Cube will be made.

III. *To make a Parallelipiped.*

1. Make a Parallelogram A B C D, and lengthen the sides A C, B D, above and below.

2. Mark any distance above AB you please, as AE, BF; and mark the same under C D as CG, DH, then joyn E, F, and G, H, together.

3. Above E F, mark the distance A C or BD, at I and K: and joyn I, K, together.

4. Lengthen EF and AB; upon the lengthened Lines mark the distance AC, or BD, as FL, BM, EN and AO.

5. Joyn L and M, N and O, together, and your Parallelipiped will be made.

IV. *To make a Cylinder.*

1. Make a long Square A B C D.

2. Divide A B into twenty two equal parts.

3. Upon what Point you please raise a Perpendicular, of the length of seven of these twenty two parts, as F. G.

4. Upon the Line D C mark the distance F B, as D H.

5. Let fall a Perpendicular from H of the length of F G, as H I.

6. Divide F G and H I into two equal parts: and from their middle Points draw Circles: and the Cylinder will be made.

V. *To make a Cone.*

1. From the Point A taken at pleasure draw an Arch.

2. Divide it into twenty two equal parts; and joyn the Extremities G, H, with A.

3. Let fall a Perpendicular where you please from the Arch, equal to seven of those parts as B C.

4. Divide B C into two equal parts, from its middle point, draw a Circle, which shall be a Base of a Cone made upon the Arch G H.

VI. *To make a Pentaedral Prism.*

1. Make a right-angled Parallelogram A B C D.

2. Divide A B and C D into three equal parts, as A E, E F, F B, and C G, G H, H D.

3. Joyn E G and F H together by right Lines.

4. From E, and F make two Arches to intersect in I, and joyn I E, and I F together.

5. Upon G H make an equilateral Triangle K, and your Prism will be made.

VII. *To*

VII. *To make an Octaëdron.*

1. Upon one Line make three equilateral Triangles, as A B C, B D E, and D F G.

2. Lengthen the Line C G; and mark upon the lengthened Line the distance E G, as G H.

3. Joyn H, F together, and with the same distance from D, F, make 2 Arches to intersect at K, and from C, E, two others to intersect at I.

4. Joyn C I and I E together, as also D K and F K, and the Octaëdron will be finished.

VIII. *To make a Dodecaëdron.*

1. Make a regular Pentagon A B C D E: the Center whereof may be F.

2. Take the distance A F, and therewith from every side draw two Arches mutually intersecting, as A B G, B C H, C D I, D E K, and E A L.

3. From the Points G, H, I, K, L, with the distance A B, describe five Circles, and divide each of them into five equal parts: and you will have five other equal Pentagons about your first.

4. With the distance H M or H N from M and N draw two Arches to intersect each other

other in O: from this Point, by the ſame diſtance, draw another Circle thro' N and M, and divide it as you did the other into five equal parts, and as M, N, P, Q, R, and there joyn them all together.

5. Take the diſtance O N, and from P, and Q draw two arches to interſect each other in S: which is a Center from whence a Circle ſhall be drawn thro' P Q, which ſhall afterwards be divided into five equal parts, Q P, P W, W U, U T, and T Q.

6. Repeat the ſame operation upon T Q, T U, U W, and W P, and your Dodecaedron will be finiſhed.

IX. *To make an Icoſaëdron.*

1. Make five equilateral Triangles upon the ſame Line, as A B C, B D E, D F G, F H I, and H K L.

2. From the Points A C make two arches which ſhall interſect each other in M.

3. Joyn A M and M L together by right Lines.

4. Upon M C raiſe the equilateral Triangle N, upon C E, O; upon E G, P; upon G I, Q; and laſtly upon I L, R.

5. Repeat the ſame operation upon their Baſes: for inſtance, ſet the equilateral Triangle S upon A B; the Triangle T upon B D;

B D; the Triangle U upon D F; W upon F H; and at last the Triangle X upon H K; which will finish the Icosaedron.

X. *To make a solid Rhomb.*

1. Upon the same Line make four equilateral Triangles. G I M, I K N, K L O, L H P.

2. Joyn M, P together by a right Line: as also G M, I N, K N, L O and H. P.

3. Add to the Line N I its own length beyond it, as I Q.

4. Add to the Line O K double its own length, as K R, R S.

5. Joyn R I and S Q together.

6. Add to the Line I R its own length beyond it as R T: do the same to N H, as H V: then joyn V, T, together, and your solid Rhomb is made.

XI. *To make a solid Rhomboid.*

1. Make an equilateral Triangle A B C, and from B C another D.

2. Add to the Line C D twice its own length, as D E, E F.

3. Add to D B its own length, as B G.

4. Add to C B thrice its own length, as B H, H I, I K.

5. With the distance I B from the point G make an arch.

6. Make

6. Make another arch with the distance B G from I which shall interlect the first at L, and joyn G, L and L, I by right Lines.

7. Add to G H thrice its own length; HM, MO, & OP, and joyn M and I together.

8. From K, and M draw two Arches to interlect at N, and joyn K N, N M, M D, O E, and P F together: and the Rhomboid will be finished.

XII. *To make a Polyëdron whose Base may be a Pentagon.*

1. Make a Square A B C D: and divide A B and C D into five equal parts, as C E, E F, F G, G A, H D; as also A I, I K, K L, L M, and M B.

2. Joyn E I, and F K, and G L, and H M, and D B together.

3. Divide one part of each of these Lines into twenty two equal parts: as F G and K L.

4. Divide one of those twenty two parts into three other equal parts.

5. Take eighteen of these twenty two parts, and ⅓ of one more, as F N, and K O; and draw two arches from K, L, as also from F, G, which shall interlect in P and Q: from P, and Q as Centers draw two Circles, which being divided into five equal parts by the distances F G and K L, your Figure will be compleated.

CHAP.

CHAP. IV.

Of PYRAMIDS.

PROBLEMS.

I. *To make a Triangular Pyramid.*

1. FRom the point A taken at pleaſure draw an arch, which divide into three equal parts, BC, CD and DE.

2. Joyn AB, AC, AD and AE with right Lines; as alſo BC, CD, and DE with other right Lines.

3. From the points C, D, with the diſtance CD, draw two Arches to interſect in F.

4. Joyn CF and DF, and the Pyramid will be compleated.

II. *To make a Pyramid with an equilateral Square for its Baſe.*

1. From the point A draw an Arch: divide it into four equal parts, BC, CD, DE, and EF, which are to be joyned together by right Lines, as alſo AB, AF, AC, AD, and AE.

2. From the point C, let fall a Perpendicular equal to CD, as CG.

3. With the diſtance CG from G, D, draw two Articles to interſect each other in H.

4. Joyn HG and DH together by right lines and you have the required Pyramid.

III.

III. *To make a Pyramid whose Base is a Parallelogram.*

1. From the point A draw a circle, in which first mark a larger arch, as B C, then a smaller one, as C D, then mark a third arch (D E) equal to the first, and a fourth (E F) equal to the second.

2. Joyn A B, A C, A D, A E, A F, as also B C, C D, D E, E F by right lines.

3. From C let fall a Perpendicular equal to C D, as C G.

4. Take the distance C G, and from B draw an arch.

5. Take the distance B C, and from G draw another arch to intersect the first in H; joyn B H and H G together, and the Problem is finished.

IV. *To make a Pyramid with an Equilateral Pentagon for its Base.*

1. Draw an arch from A, which divide into five equal parts, B C, C D, D E, E F, F G.

2. Joyn them all to A, and one to another, B to C, C to D, D to E, E to F, F to G, by right lines.

3. Divide one of these five parts, as D E, into twenty two equal parts, and one of them into three.

4. Take

4. Take eighteen of the twenty two parts, and two of the three little parts, and from the points D E, make two arches to interſect each other in H, which is the Center, from whence you are to draw a circle big enough to be divided into five parts, equal to the diſtance D E. When you have this Pentagon for a Baſe, the work is done.

V. *To make a Pyramid, which ſhall have an Equilateral Hexagon for a Baſe.*

1. Draw an arch from A, and divide it into ſix equal parts, B, C, D, E, F, G, I.

2. Joyn them to the center A, as alſo B to C, C to D, D to E, E to F, F to G, G to I.

3. Take one of theſe ſix parts (D E) and from D and E make two arches to interſect in H.

4. From H draw a circle big enough to be divided into ſix parts equal to D E.

5. Having this Hexagon as a Baſe for the Pyramid, the Problem is wrought.

VI. *To make a Pyramid with a Heptagon for its Baſe.*

1. From A draw an arch, and divide into ſeven equal parts, B, C, D, E, F, G, H.

2. Joyn them to A, and alſo B to C, C to D, D to E, E to H, H to G, G to F, F to I, by right lines.

3. Divide

3. Divide one of these parts, F G for instance, into seven equal parts, and then one of these seven into eight more; then take eight of the larger parts, and the half of a little one, and with that distance from the points F G, make two arches to intersect each other in K; for which as a center draw a circle thro' F G, which must be divided into seven parts equal to F G, which when joyned together, will serve for a Base of the Pyramid required.

VII. *To make a Pyramid with an Octagon for its Base.*

1. From A draw an arch, divide it into eight equal parts, B, C, D, E, H, I, F, G, joyn these points one to another, and also to A by right lines.

2. Divide one of these parts, as F G, into seven equal parts, and one of these seven into seven others.

3. Take nine of the larger, and one and a half of the smaller parts, and with that distance from F and G, make two arches to intersect each other in K.

4. From K thro' F G draw a circle, divide it into eight parts equal to F G, and then joyn them by right lines: so you'll have an Octagon to be a Base to the Pyramid requir'd.

VIII. *To*

VIII. *To make a Pyramid with an Enneagon for its Baſe.*

1. From A draw an arch, and divide it into nine equal parts, B, C, D, E, F, G, H, I, K; joyn theſe together, and with A by right lines.

2. Divide any one of theſe parts, as K M, into ſeven equal parts, and one of them into ſeven more.

3. Take ten of the former, and two of the latter, and from the points K M make two arches to interſect each other in L, with the length of thoſe parts, as a given diſtance.

4. From L draw a circle thro' K M, which muſt be divided into nine parts equal to K M; joyn theſe together by right lines: ſo you have the Enneagon which was wanted for a Baſe for the Pyramid required.

IX. *To make a Pyramid with a Decagon for its Baſe.*

1. From A draw an arch, which divide into ten equal parts, to be joyned to each other, and to A, as B, C, D, E, F, G, H, I, K, L.

2. Divide one of theſe ten parts into ſeven, and one of theſe ſeven into eight more.

3. Take eleven of the former, and two and a half of the latter, and with that distance from I K, draw two arches which shall intersect each other in M.

4. From M draw a circle thro' I K, which divide into ten parts equal to I K, and there will be a Decagon for a Base to the Pyramid.

X. *To make a Pyramid with an Endecagon for its Base.*

1. From A draw an arch, and divide it into eleven equal parts, to be joyned each to other, and all to A, as B, C, D, E, F, G, H, I, K, L, M.

2. Divide one of them (F G) into seven equal parts, and one of these seven into seven more.

3. Take twelve of the former, and one and a half of the latter, for a distance, whereby from F G to draw arches which shall intersect each other in N.

4. From N draw a circle thro' F G, which may be divided into eleven parts equal to F G; joyn them together, and you have the Base of the required Pyramid.

XI. *To make a Pyramid with a Dodecagon for its Baſe.*

1. From A draw an arch, which divide into twelve equal parts, which are to be joyned to A, and each to other by right lines, as B, C, D, E, F, G, H, I, K, L, M, N.

2. Divide any one (F G) into ſeven equal parts, and one of theſe ſeven into ſeven others.

3. Take thirteen of the former, and one and a half of the latter, for a diſtance whereby from F G to draw two arches which ſhall interſect each other in O.

4. From O draw a circle thro' F G, and divide into twelve parts equal to F G, which when joyned by right lines, will give a Baſe of the Pyramid that was required.

BOOK II.

AS all Rivers have their particular Branches, and every general Science its Diviſions, and its Parts; ſo Geometry, generally taken, is the Mother of ſeveral other Arts and Sciences, whereof we ſhall treat in this Second Part. Theſe are, Meaſuring of Heights, of Diſtances, of Plains, of Solids, of Concaves, and the turning of one Body into another.

CHAP. I.

Of Meaſuring of Heights.

MEaſuring of Heights is a Science which ſhews how they are to be meaſured: But becauſe there are ſeveral Inſtruments for that purpoſe, as a Quadrant, a Pantometre, an Aſtrolabe, a *Jacob's* Staff, *&c.* We ſhall at preſent only make uſe of the Aſtrolabe, becauſe it is the ſureſt and the moſt convenient: and we ſhall know how it is to be uſed by the following Problems.

PROBLEMS.

PROBLEMS.

1. *To take the Vertical Height of any thing, when you can come to the bottom.*

Let the height of a Tower A B be to be measured.

1. Draw a right Line as you please from the point *A*, as A C.

2. Measure the Line A C with your Scale, or your Chain, of 26 Feet for instance.

3. Set the Staff, upon which the Astrolabe is Horizontally fastned, upon C, so that by the fixed Sights, one may see the Line C A, from one end to the other, as far as the Tower, and that by the two other movable sights the point B, which marks the height of the Tower, may also be seen.

4. When the Instrument is thus fixed, compute whether the Angle CDE be 40 degrees.

5. Then draw upon Paper a right Line of the length of A C, as F G: But this must be done by a small Scale made upon the Paper, or by a Scale of Wood or Latten: Afterwards erect a Perpendicular upon G.

6. Take the Reporter [the *French* word is *Rapporteur*] and set it directly upon F G, so that the middle of it may answer to the point F: then compute an Angle of 40 Degrees equal to C D E, as F H I.

7. From F draw a right Line thro' I, till it touches the Perpendicular G in K.

8. With a small Scale measure the height of K G, and add the height of the Staff to which the Astrolabe is fastned, and the Sum will give you the height of the Tower A B.

II. *To measure a Vertical Height where you cannot come at the bottom.*

Let A B be the height to be measured; the foot inaccessible, because of a River which hinders all approaches.

1. Draw a right Line upon the Ground, on this side of the River, as C D; let it be 22 Foot long: (Take notice, when you can raise a right-angled Triangle upon this Line, opposite to the height which you would measure, it is much more convenient, otherwise the Operation is the same.)

2. Set the Instrument upon C, so that by the immovable sights you may see the point D directly, and by the two movable ones you may see the point A beyond the River: When this is done, compute the Angle C E F, which may be of 90 Degrees.

3. Set the Instrument upon D, so that the fixed sights may make one Line with D C; by the two others you will see the point A: this Angle ought to have 28 Degrees.

4. Draw

4. Draw upon Paper a Line equal to that drawn in the Field (C D) as G H of 22 Feet.

5. With the Reporter take an Angle at H equal to the Angle C E F, *viz.* of 90 Degrees, as I H K, and lengthen the ſide H K. Afterwards upon the Point G take another Angle of 28 Degrees, equal to the Field-Angle D O P, as G L M, and then lengthen the ſide G M till it cuts the other H K, in N, and this Point N will mark the foot of the height A.

6. Having the diſtance from the Inſtrument to the foot of the Tower, it will be an eaſie thing to work the reſt by the foregoing Problem.

III. *To meaſure a Perpendicular Height, where you can come at the bottom, with the ſhadow of a Staff.*

1. Faſten a Staff a foot long perpendicularly into the ground, as A B, and meaſure the ſhade by the Staff, 3 Foot for Inſtance.

2. With the ſhade of the Staff, *viz.* 3 feet, meaſure the ſhade of the Houſe D E, whoſe height you would know; and as many feet as the ſhade of the Houſe exceeds the ſhade of the Staff, ſo many foot high will the Houſe be: For Inſtance, if the ſhade of the

Houſe be 24 times longer than that of the Staff, then we ought to ſay that the Houſe is 24 Foot high.

Or thus,

1. Erect a Stick, divided into 10 equal Parts, Feet, or Inches, perpendicularly in the ground, and at the ſame time meaſure the ſhade cauſed by this Staff, 20 Foot for Inſtance.

2. Meaſure alſo the ſhadow of the Houſe, whoſe height you would know, for Inſtance 38 Feet.

3. By the *Rule of Three* ſay, If the ſhadow of 20 Foot gives a height of 10 Foot, what will the ſhadow of 38 Foot give? *Anſw.* 19 Foot.

IV. *To meaſure the Inclination of a Mountain.*

Let the Inclination of the Mountain A B be to be meaſured.

1. Draw from the Point A, which ſtands for the foot of the Mountain, a right Line, 36 Foot long, as A C.

2. Set the Inſtrument upon the Point A, and look thro' the two fixed ſights towards the Point C, and thro' the two movable ones towards the Point B, the top of the Mountain; this Angle, for Inſtance, may be 110 Degrees.

3. Then

3. Then set the Instrument upon C, and look thro' the two fixed sights upon the foot A, and thro' the two other fixed ones upon the top B: then compute this Angle, which may be for Instance 40 Degrees.

4. Afterwards, draw a Line upon Paper, 36 Foot long, because it ought to be equal to the Line A C, as D E.

5. Then by the Reporter set upon D an Angle equal to that of the Figure at A, *viz.* 110 Degrees, as D F G.

6. Upon the Point E, set another Angle of 40 Degrees, equal to that at C, as E H I.

7. Lengthen the sides D F and E I, and where these lengthened Lines intersect one another, as at K, draw from that Point to D a right Line, which will represent the Inclination which was required, provided the height of the Staff upon which the Astrolabe was fastned, be added.

V. To measure the vertical height of a Mountain.

This Problem must be wrought as the foregoing one, provided that you let fall a Perpendicular from the Point K, which marks the top of the Mountain, which must touch the Line C D lengthned to L; the Line K L will represent the vertical height of the Mountain.

VI. *To*

VI. *To measure the height of a Tower built upon a Rock.*

Let the height B D be to be measured.

1. Seek the inclining height of the Mountain by *Prob.* 4. and let the Triangle A B C demonstrate its Operation.

2. Make the Triangle H I K upon Paper equal to the Triangle A B C.

3. Measure the Field-Angle C B D, for Instance 38 Degrees.

4. Upon K, which represents the Point B, and so by consequence the top of the Mountain, raise a Perpendicular of what length you please.

5. With the Reporter raise upon the Point I an Angle equal to the Angle of the Figure A B C D, *viz.* I L M.

6. Lengthen the side I M till it touches the Perpendicular raised upon K in N.

7. Measure the Line N K, it will give you the height of the Tower B D, if you add to it the height of the Staff.

VII. *To measure the depth of a Well.*

1. Measure its Diameter A B, 9 Foot for Instance: and find the Angle B C D of 90 Degrees.

2. Set

2. Set the Instrument so upon A, as that by the two fixed sights you may see the Point B, and by the two movable ones you may see the bottom of the Pit E, and let this Angle be 60 Degrees, as A H I.

3. Draw a Line 9 Foot long upon Paper, which shall represent the Diameter A B, as F G.

4. From F let fall a Perpendicular which may represent the depth B E.

5. Make an Angle at G equal to the Angle A H I, *viz.* of 60 Degrees, as G K L.

6. Lengthen the side G L, and where this lengthened Line touches the Perpendicular E, as in M, measure from M to F, and you will have the depth of the Well.

CHAP. II.

Of Measuring of Distances.

MEasuring of Distances is a Science which teaches to measure the Distance of one place from another, in an open Field.

Problems.

I. *To measure the Distance of one place from another, where they are both accessible.*

Let the Distance from A to B, be to be measured.

1. From A draw a right Line, what you please, and measure with a Chain or Scale; suppose 22 feet in length, as A C.

2. Set the Staff upon which the Astrolabe is fixed, upon the Point A, so as that by the two fixed sights, you can only see directly forward towards the Point C, and by the two others the Point B: then count the Angle A D E, suppose 90 Degrees.

3. Remove the Instrument upon C, and look thro' the fixed sights towards A, and thro' the movable ones towards B; then compute this Angle C F G, suppose 22 Degrees.

4. Draw a Line upon Paper 22 feet long, equal to the Line A C, as H I.

5. With the Reporter upon the Point H draw an Angle equal to the Angle A D E, that is to say, of 90 Degrees, as H K L: do the same thing at I, where make another Angle equal to the Angle C F G, *i. e.* of 22 Degrees, as I M N.

6. Lengthen

6. Lengthen the sides H K, I M, and from the Point where these two lengthned Lines intersect each other, as O, to the Point H, measure the Distance, which shall be equal to the length A B.

II. *To measure the Distance of two places, whereof one is inaccessible.*

Let the Distance from A to B be that which is required, and B inaccessible, because of a River which hinders all approaches.

1. From A draw a right Line 22 Feet long, as A C.

2. Set your Instrument upon A, and look thro' the two fixed sights upon the Point C, and thro' the two movable ones upon B: then compute the Angle A D E of 93 Degrees.

3. Carry the Instrument to C, and look thro' the two fixed sights upon the Point A, and thro' the two others upon B, and then compute the Angle C F G of 33 Degrees.

4. Draw upon Paper a Line equal to A C, *i. e.* of 22 feet, as H I.

5. Upon H make an Angle equal to the Angle of the Figure A D E, *i. e.* of 93 Degrees, as H K L. So also upon I make another Angle equal to the Angle C F G, as I M N.

6. Lengthen

6. Lengthen the sides H K and I M, and in the place where they intersect, as at O, let fall a Perpendicular upon H, which will give you the Distance A B.

III. *To find the Distance of two places which are both inaccessible.*

Let the Distance A B be to be measured.

1. Take a fixt Point C, from which draw a right Line C D, which shall be 33 Foot long.

2. Set the Instrument upon C, and look thro' the two fixed sights upon the Point D, and thro' the two others upon the Point A: then compute the Angle C H K for Instance of 90 Degrees.

3. Leave the Instrument as it is, and remove the movable sights, till thro' them you may see the Point B, and then compute that Angle, for Instance 36 Degrees, as C H I.

4. Carry the Instrument to D, and fit it so, as that thro' the fixed sights you may see the Point C, and thro' the two other movable ones the Point B: then compute this Angle, which may be of 100 Degrees, as D E G.

5. Leave the Instrument as it is, and turn the movable sights till you may see the Point A thro' them; then compute that Angle, of 30 Degrees, as D E F.

6. After-

6. Afterwards draw a Line of 33 foot upon Paper, to repreſent the Line CD, as L M.

7. With the Reporter ſet two Angles at L, one of 90 degrees, and the other of 36 degrees, ſo that the firſt L N O may repreſent the Angle C H K, and the other L N P the Angle C H I.

8. Lengthen the ſides L O and L P.

9. Add two Angles to the other Point N, one of 100 degrees, as M Q R, to repreſent the Angle of the Figure D E G, and the other of 30 degrees, as M Q S, to repreſent the Angle D E F.

10. Lengthen the ſides M R, M S, and obſerve where theſe two lengthened Lines touch the two firſt, as at T V. For this diſtance T V will give you the diſtance A B, which was required.

IV. *To meaſure the breadth of a River with a Staff.*

1. Fix a Staff perpendicularly upon the bank of a River, as A.

2. Cleave it at the end, and faſten a croſs-ſtaff into the cleft, as B C.

3. Stand behind the ſmall croſs-ſtaff B C, and uſe it as you would the ſights of an Aſtrolabe, *i. e.* move it downwards, till from

B C

BC you can see the other side of the River at PA.

4. Afterwards letting the small Staff stand as it is, turn the large one perpendicularly, till from BC you can see the whole length of the Bank: Then stand behind B, and observe the last place where from C you can see the Bank on the other side, as at E.

5. Measure the distance EA, it will give you the breadth of the River AD.

V. *To describe a Figure taken from the Field upon Paper.*

Let the Figure to be described be ABCDE.

1. Set the Staff to which the Astrolabe is fixed, upon the Point E, and look upon the Point D thro' the fixed sights, and thro' the two movable ones upon the Point A. Then compute this single Angle EAD, 60 degrees for Instance.

2. Measure the Line AE of 23 feet.

3. Measure another Line ED of 24 feet.

4. Set the Instrument upon D, and look towards C with the fixed sights, and with the movable ones towards E: Then compute this Angle, of 70 degrees for Instance, as DEC.

5. Let the side DC be of 28 feet.

6. Seek

6. Seek the Angle C d b after the aforesaid manner, and let it have 50 degrees.

7. Measure the Line C B, for Instance, of 13 feet.

8. The side B A will be found of it self.

When this is done in the Field, then

1. Draw a Line upon Paper 23 foot long, to represent the Figure A E, as K F.

2. With a Reporter make at the Point F an Angle equal to the Angle of the Figure E d a, *i. e.* of 60 degrees, as F k g.

3. Lengthen the side of this Angle F g, and add its length to it, *i. e.* 24 feet, as F G.

4. Upon G make an Angle equal to that of the Figure D e c, *i.e.* of 70 degrees, as G f h.

5. Lengthen the side G h, and add the side D C, *i. e.* of 28 feet, as G H.

6. Upon the Point H set another Angle equal to that of the Figure C d b, of 50 degrees, as H g i.

7. Lengthen the side H i, and add 13 feet to it, as H I, which may represent the side C B.

8. Joyn I K together by a right Line, which will give the last side of the Figure B A, and which at the same time will entirely represent the given Figure upon Paper.

VI. *To describe upon Paper a Figure taken from the Field, which is inaccessible.*

Let the Figure A B C be to be described upon Paper from the Point D.

1. From D draw a right Line D E 32 foot long.

2. Set the Instrument upon D, and look thro' the fixed sights towards E, and thro' the two moveable ones towards A: Then compute the Angle D f g, of 105 degrees.

3. Leave the Instrument as it is, and remove the moveable sights till you can see the Point B, and compute the Angle D g h of 90 degrees.

4. Leave the Instrument still as it is; look thro' the moveable sights towards the Point C, and compute the Angle D g i of 60 degrees.

5. Set the Instrument upon E, and look thro' the fixed sights towards the Point D, and thro' the moveable ones towards A, and compute the Angle E k l, for Instance of 50 degrees.

6. Leave the Instrument as it is, and look thro' the moveable sights towards B, and compute this Angle E k m of 70 degrees.

7. Look thro' the same sights towards the Point C, and then compute the Angle E k n, for Instance of 90 degrees. This

This being done in the Field, then

1. Draw a Line of 32 feet upon Paper, as O P, equal to the Line D E.

2. Take an Angle of 105 degrees at O, as O q r, which may repreſent the Angle of the Figure D f g, and lengthen the ſide O q.

3. Leave the Reporter as it is, and compute another Angle of 90 degrees, as O r s, to repreſent the Angle D g h, and lengthen the ſide O s.

4. Seek the laſt Angle of 60 degrees O r t, which may repreſent the Angle of the Figure D g i, and lengthen the ſide O t.

5. Set the Reporter upon the Point P, and compute an Angle of 50 degrees, to repreſent the Angle E k l, as P a b; lengthen the ſide P b till it meets with the ſide O q in C: for this point of Interſection will mark the Point A.

6. Leave the Reporter as it is, and compute another Angle of 70 degrees, which may repreſent the Angle E k m, as P a d; lengthen the ſide P d till it cuts the lengthned Line O s in E, which Point will mark the Point B in the Figure.

7. Compute another Angle of 90 degrees equal to the Angle E k n as P a f; lengthen the side P f till it meets with the lengthned Line O t in G, which answers to the point C in the Field-figure.

8. Joyn C E, E G, and G C together, and you shall have your Figure A B C represented upon Paper.

CHAP. III.

Of measuring of Plains.

MEasuring of Plains is a Science which teacheth us to measure all sorts of Surfaces of Things, which Geometricians call *Area's*.

PROBLEMS.

I. *To measure the Area of a right-angled Triangle A B C.*

1. Measure the Line A B, 12 foot long for the Base.

2. Measure the Perpendicular B C, of 8 foot.

3. Multiply the half of the Base upon the whole perpendicular, or the half of the perpendicular upon the whole Base, and the Sum,

(48 foot) will be the Area of the Triangle which was deſired.

II. *To meaſure the Area of an Oblique-angled Triangle D E F.*

1. Let fall a perpendicular from F to its oppoſite ſide DE, which may divide the Triangle into 2 right-angled Triangles, D G F, and F G E.

2. Meaſure theſe two Triangles by the foregoing Problem; *i. e.* multiply the whole Baſe DG and GE, by the half of the Perpendicular F G, or the whole Perpendicular by the half of the Baſe D G and G E.

Thus for inſtance: Let the Baſe D G be 12 foot, and the Perpendicular F G 10: Take the half of the Perpendicular, *viz.* 5 feet, and multiply it by the Baſe of 12 feet, and the ſum will be 60 feet, which gives the Area of the Triangle D F G.

3. Let the Baſe G E of the Triangle F G E be ſix feet, and the Perpendicular F G ſtands as it did, *i. e.* to feet. Multiply 5 by 6, or or 3 by 10; the ſum will be 30 feet, which will give the Area of the Triangle. Then add 30 to 60, the ſum 90 will be the number of feet in the whole Area of the given Triangle D E F.

REMARKS.

Sect. 1. If one of the Lines to be multiplied has only fathoms, and the other fathoms and feet; when you multiply, inſtead of a fathom take 6 foot. For inſtance: if you are to multiply 7 fathoms by 8 fathoms and 4 feet, inſtead of the firſt ſum (ſeven fathoms) you muſt put 6 fathoms and 6 feet, becauſe theſe 6 feet make but one fathom: For ſince there are no feet expreſſed, you cannot any otherwiſe multiply the feet of the ſecond ſum; So the number will be 48 fathoms, and 24 feet: for 6 into 8 gives 48: and 6 into 4 gives 24.

Sect. 2. If one of theſe lines has only fathoms, and the other has fathoms, inches, and feet; for inſtance, if you are to multiply 6 fathoms by 8 fathoms, 4 feet, and 6 inches, this is the Method you are to take:

1. Bring theſe 8 fathoms, 4 feet, and 6 inches, into one Line.

2. Inſtead of 6 fathoms, take 5 fathoms and 6 feet; and put the firſt cypher 5 under 8, becauſe they both mark fathoms: take one out of the ſecond cypher 6, ſo as that there may be but 5 feet to put under the feet of the firſt ſum: divide the foot which you ſubſtracted into 12 inches, for 12 inches

are

are equal to a foot: then ſet the inches under the 6 inches of the firſt ſum.

Sect. 3. Reduce the feet into fathoms, dividing by 6; divide alſo the inches by 12, and it will give you the feet: for inſtance, 72 inches gives 6 feet, and 20 feet give 3 fathoms and 2 feet.

III. *To meaſure the Area of an equilateral right-angled Square A B C D.*

Multiply one ſide by the other: AB for inſtance of 12 feet, by BC of 12 feet: becauſe the ſides are equal: the product 144 feet will give you the Area which is ſought for.

IV. *To meaſure the Area of a Parallelogram A B C D.*

Multiply the ſhorteſt ſide BC of ſix foot, by the longeſt ſide A B of 12 foot: the product 72 foot will give you the Area of the Parallelogram which was required.

V. *To find the Area of a Rhomb, A B C D.*

1. Let fall a Perpendicular from A to the Line D C, as A E.

2. Let fall another Perpendicular from B, equal to A E, as B F; and joyn C F together. So that inſtead of a Rhomb you have a Parallelogram A B E F: then work by the foregoing Problem. See Prob. 28. Book. 1. Chap. 2.

VI. *To find the Area of a Rhomboid A B C D.*

1. Let fall a Perpendicular from A to the oppoſite Line D C, as A F.

2. Let fall another from B, equal to A F, as B E.

3. Joyn C E together, and inſtead of the Rhomboid A B C D you have a Parallelogram A B E F: You will find its Area by the 1ourth Problem of this Chapter.

VII. *To find the Area of any unequilateral Quadrangle.*

Let the given Quadrangle be A B C D.

1. Divide this Quadrangle into two Triangles A B D, and C D B.

2. Divide each of theſe Triangles into two right-angled ones, as A B F, B C E, A D F, D E C.

3. When you have theſe 4 right-angled Triangles, ſearch their Area's by the two firſt Problems of this Chapter: then joyn the

the Sum of all theſe Triangles together, and it will give the Area which is required.

VIII. *To find the Area of any regular Polygon.*

Let the regular Pentagon demanded be A B C D E.

1. Meaſure one ſide of the Polygon as A B, for inſtance, 6 fathoms: multiply this number by the number of the ſides of the Polygon, as here by 5, becauſe this Polygon has but 5 ſides: the product of this multiplication will give you the length of all the ſides.

2. Let fall a Perpendicular from any ſide to F the Center of the Polygon, as F G: then meaſure this Line, 5 fathoms for inſtance.

3. Multiply the ſum of all the ſides, by the half of the Perpendicular: the product will give the Area which is required.

IX. *To find the Area of any irregular Polygon A B C D E.*

1. Divide the whole Figure into right angled Triangles; as this irregular Pentagon A B C D E into A B G, B C G, A D H, C D H, A E F, and D E F.

2. When

2. When you have only right angled Triangles, work by the first Problem of this Chapter; the sum of all the Triangles reduced to one, gives the Area which is fought for.

X. *To find the Area of a Circle.*

Reduce this Circle to a right angled Triangle, by *Prob.* 21. *Book* 1. *Chap.* 2. and then seek the Area by the Rules of the first Problem of this Chapter.

XI. *To find the Area of an Oval Figure.*

1. Divide the proposed Figure into four equal parts, as A B C D, so as that the line A B may make one Diameter, and C D another.

2. Seek for a mean proportional between these two Diameters, which you may thus find:

Set the Diameter A B upon a long line, and upon the same line from the point B, set the other Diameter C D, as B C; then take the half of the distance between A and C, and carry it on to B, as E B; this shall be a mean proportional; then divide E B into two equal parts, as E F, F B; then draw

a

a Circle from the point F thro' the point E B, which shall be equal to the given Oval Figure.

3. Having this Circle, find its Area, by the foregoing Problem; *i. e.* raise a Perpendicular upon B, one extream point of the Diameter, which shall have thrice the length of the Diameter E B, and a seventh part over, as B G.

4. Joyn F the Center of the Circle to the point G by a right line, which will give a right angled Triangle equal to the given Circle; its Area may be found by the Rules of the first Problem of this Chapter.

[This Triangle which he says is equal to the Area of the Circle is not expressed in the Scheme.]

XII. *To measure the Surface of any Equilateral Pyramid.*

1. Let A B C D be an equilateral Square, which shall be the Base of the Pyramid given.

1. Find the Area of this Base by Prob. 3. of this Chapter, of 48 foot.

2. Multiply one of its sides, as A B, by the height of the Pyramid E F, that is 12 by 28, whose product will be 336 feet.

3. Multiply

3. Multiply 336 by 4, the number of the ſides of this Pyramid, and the product will be 1344 feet.

4. To this ſum add the Area of the Baſe, 48 feet, and you will have the total ſum of the Area of the Pyramid propoſed, *viz.* 1392 feet.

XIII. *To find the Convex Surface of a right lined Cylinder.*

1. Set the height of the Cylinder B D upon a long line.

2. Set upon the ſame line, beginning at the point D, the Diameter of the Baſe of the Cylinder marked C D, as D E.

3. Divide the line E B into two equal parts, B F, E F.

4. With the diſtance F D draw a Circle, which ſhall contain the Convex Surface of the given Cylinder: this you may find by *Prob.* 21. *Chap.* 2. of the firſt Book, which teaches you to make a right angled Triangle equal to a given Circle; when you have this Triangle, find its Area by Prob. 1. of this Chapter.

5. When you have the Area of this right angled Triangle, which repreſents the Convex Surface of the Cylinder, then find the Area of the two Baſes of the Cylinder by Prob.

Prob. 1. of this Chapter: Add the ſum of the two Baſes to the Area of that Triangle which gives you the Convex Surface of the Cylinder, without counting the Baſes, and you will have the general ſum of the whole Surface of the Cylinder, with both its Baſes. See *Archimedes de Sphærâ & Cylindro*, lib. 1. Prop. XIII.

XIV. *To find the Convex Surface of a regular Cone.*

Let the given Cone be A B D, and its diameter A D.

1. Set the height of the Cone D B upon a right line.

2. Set its ſemi-diameter C D upon the ſame line, as D E.

3. Divide E B into two equal parts, E F, F B.

4. Take the diſtance F D, and make a circle, as large as the Cone without the Baſe.

5. Reduce this circle to a right angled Triangle by Prob. 21. Chap. 2. of the firſt Book, and find its Area by Prob. 1. of this Chapter.

6. By the two forementioned Problems ſeek the area of the baſe of your Cone, and add this ſum to the former; the ſum total will

will give the whole surface of the given Cone. See *Archimed.* Lib. cit. Prop. XIV.

XV. *To measure the Convex Surface of a Globe.*

1. Measure the diameter A B, of nine feet.

2. Find the circumference of the circle, whereof that is the diameter, which is always thrice as long, and a third part over.

3. Multiply the diameter by the circumference; the product will give you the required surface of the given Globe.

XVI. *To find the Area of any Trapezium, as A B C D.*

You must work by the Rules of Problem 7. of this Chapter.

XVII. *To find the Area of the Base of a round Tower, where you can only come at one part.*

1. Measure the line A B, of fourteen fathoms, and from its middle point draw a perpendicular to the arch, as D C, of four fathoms.

2. Multiply the distance A D by the remainder D B; *i. e.* 7 by 7; then divide by

4 the number of the perpendicular D C.

3. Add to this the length of the perpendicular, *i.e.* four fathoms, and it will give you the length of the diameter, to compleat the baſe.

4. When you have found the baſe, ſeek for a right angled Triangle, equal to it, by Prob. 21. Chap. 2. Book 1; afterwards you may find the area of that Triangle by Prob. 1. of this Chapter.

CHAP. IV.

Of Meaſuring of Solids.

MEaſuring of Solids is a Science which ſhews how one is to find the Solidity of Bodies: Solidity is Magnitude with Breadth, Length, and Thickneſs.

PROBLEMS.

I. *To find the Solidity of a Parallelepiped.*

1. Meaſure the height, length and breadth of the Parallelepiped.

2. Multiply the breadth A D, of two feet, by the length A B, of four feet, and the

the sum will give you the area of the Base.

3. Multiply the number of this Area by the height of the Parallelepiped, which here shall be eight feet; and the product from thence will shew you the Solidity required, of sixty four feet.

II. *To find the Solidity of a Prism.*

1. Find the Area of the Base A B C, by Prob. 2. Chap. 3. Book 2. of six feet.

2. Measure the height C F, here of nine feet.

3. Multiply the Base by its height, *i. e.* 6 by 9, and the product 54 will give the Solidity required.

III. *To find the Solidity of a Cylinder.*

1. Find the Area of the Base by Prob. 21. Book 1. Chap. 2. and by Prob. 1. Chap. 3. Book 2. for instance five feet.

2. Find the height of the Cylinder A B, here of nine feet.

3. Multiply the Area upon the height, *i. e.* 5 by 9, and the sum 45 will give the Solidity required.

IV. *To*

IV. *To find the Solidity of Pyramids and Cones.*

1. Meaſure their height F E and A B, for inſtance, of twelve feet.

2. Find the Area of their Baſes; that of the given Pyramid by Prob. 6. Chap. 3. Book 2. of ſixteen feet; and that of the Cone by Prob. 10. Chap. 3. Book 2. of ſixteen feet.

3. Multiply the entire height by the third part of the Baſe; *i. e.* twelve feet by five feet four inches; or the whole Baſe by the third part of the height, *i. e.* ſixteen feet by four feet; the ſum ſixty four will give the Solidity of the Pyramid and the Cone; for this is equal to the given Pyramid: and becauſe we are to find its Solidity, that alſo will be equal to the Solidity of the ſame Pyramid.

V. *To find the Solidity of a Globe.*

1. Multiply the Semi-diameter A B by the Surface of the Globe, which you ſhall find by Problem 15. of the foregoing Chapter.

2. Divide this ſum by 3, and the Quo-

tient will give you the required Solidity: for inſtance, let the Semi-diameter be 28 feet, and the Convex Surface 9856 feet; multiply this by 28, and the product will be 275968; divide that by 3, and your Quotient 91989⅓ will give you the number of feet which make up the Solidity of this Globe.

VI. *To find the Solidity of a Tetraëdrum.*

Since a Tetraëdrum is nothing elſe but a triangular equilateral Pyramid, its Solidity muſt be ſought by Prob. 4. of this Chapter; *i. e.* by multiplying the Baſe by a third part of the height, or the height by a third part of the Baſe; the product will ſhew the Solidity which is required.

VII. *To find the Solidity of an Octaëdrum.*

Since an Octaëdrum is made up of two Pyramids which have one common Baſe, *i e.* an equilateral right angled Square.

1. Find the Solidity of one of theſe Pyramids by Prob. 4. of this Chapter, for inſtance of ſixteen feet.

2. Multiply theſe 16 feet by 2, the product will give the required Solidity of 32 feet.

VIII. *To find the Solidity of a Dodecaëdrum.*

If one draws from the Center of a Dodecaëdrum a right line to every angular point, one may from twelve equal Pyramids, every one whereof will have a regular Pentagon for its Baſe; upon which account

1. Find the Solidity of one of theſe twelve Pyramids, by the ſame 4th Problem, and let it be for inſtance of twelve feet.

2. Multiply theſe twelve feet by the the number of the Pyramids, *i. e.* 12; the product 144 gives the requir'd Solidity.

IX. *To find out the Solidity of an Icoſaëdrum.*

This being formed of twenty equal Tetraëdra, if one draws right Lines from its Center to every angular Point, one muſt,

1. Find the Solidity of one of theſe Tetraëdra by the ſame fourth Problem, for inſtance of 8 Feet.

2. Multiply 8 by 20, the number of the Tetraëdra; and the product 160 will ſhew the number of the ſolid feet in the given Icoſaëdrum.

X. *To find the Solidity of a Cube.*

By the third and fourth Problems of the foregoing Chapter, multiply the Area of the Base by the length, and the product gives the Solidity.

XI. *To find the Solidity of a solid Rhomb, and Rhomboid.*

Find the Area of the Base of a Rhomb by Prob. 5. of the foregoing Chapter, and the Area of the Base of the Rhomboid by Prob. 6. of the same: when they are found, multiply them by their respective lengths, as was directed in the foregoing Problem, and the product gives the Solidity required.

XII. *To find the Solidity of a Wall, Rampart, Curtain,* &c.

This is done by Problem 1. of this Chapter.

CHAP.

CHAP. V.

Of Meaſuring Concave Bodies.

MEaſuring Concave Bodies is a Science which teaches us to find their capacity that ſo we may know how much they contain: Cylindro-metrical Bodies have need of a Cylindro-metrical Scale: and Cubo-metrical Bodies have need of a Cubo-metrical Scale: So that theſe two Scales are made uſe of in the meaſuring of Concave Bodies.

PROBLEMS.

I. *To find the Capacity of a Concave Parallelepiped.*

By which I underſtand all ſquare Bodies; as Chambers, Granaries, Cellars, Towers, Pits, *&c.* So that if one would know how much they contain, he muſt,

1. With his Cubo-metrical Scale meaſure, the height, length, and depth.

2. Multiply the length by the breadth, and their product by the height.

3. Examine how many meaſures the whole

ſum takes up upon the Scale, and ſo the required Capacity may be found.

II. *To find the Capacity of a Ditch.*

1. Meaſure its breadth at the top, AF, 15 Fathoms and 1 foot.

2. Meaſure its breadth at the bottom CD 11 fathoms 5 feet.

3. Meaſure its depth CG, 9 fathoms.

4. Meaſure its length, 496 fathoms.

5. Add the 2 breadths together, and multiply the half of the ſum by the length of the Ditch; there will be 6438 fathoms.

6. Multiply theſe 6438 fathoms by the depth 9 fathoms, and the product will be 57942 fathoms, or 347652 feet, which gives the Capacity requir'd.

III. *To find the Capacity of Columns, Towers, and other Priſms.*

1. With a Cubo-metrical Scale meaſure the height of the Priſm.

2. Find the Area of the Baſe.

3. Multiply that number by the height, and you will find the Capacity.

IV. *To*

IV. *To find the Capacity of any regular Pyramid.*

1. Meaſure the Area of the Baſe with a Cubo-metrical Scale.

2. Meaſure the height likewiſe, the ſame way.

3. Multiply the height upon the Area of the Baſe.

4. Divide the Product by 3, and the Quotient will give you the Capacity.

V. *To find the Capacity of a Cone.*

1. Meaſure the Area of the Baſe with a Cubo-metrick, or Cylindro-metrick Scale.

2. Multiply this number by the third of the height.

3. Divide the Product by 3, and the Quotient will give you its Capacity.

VI. *To find the Capacity of a Cylinder.*

1. With a Cylindro-metrical Scale find the Area of its Baſe.

2. Multiply that by the height of the Cylinder; the Quotient gives its Capacity.

VII. *To find the Capacity of a Cylinder whoſe Baſes are unequal.*

1. Find the Area of each Baſe by the Cylindro-metrick Scale.

2. Add the ſums together, and multiply its height by the half of that ſum; the Quotient will give its Capacity.

VIII. *To find the Capacity of a Barrel whoſe Heads are equal.*

We muſt take notice that the Rod by which a Veſſel is to be gauged, is marked with different meaſures; and ſo one ſide of the Gauging-Rod is for the length of a Barrel, and the other for the depth: In anſwer therefore to the Queſtion propos'd,

1. Meaſure the Area of the bottom A B.

2. Meaſure the thickneſs with the Gauging-Rod, and by that take the Surface of the Belly of the Barrel.

3. Add theſe two ſums together, and multiply the half by the length of the Veſſel, ſo the Product gives you its Capacity.

IX. *To*

IX. *To find the Capacity of a Barrel whose Heads are unequal.*

1. Measure the Diameter of the Head A, and by this known Diameter, measure its Surface.

2. Measure the other Diameter E F, and thereby find the Area of that Head.

3. Add these two sums together.

4. Find the depth of the Barrel C D, by which you find the Surface of its Circumference; by Prob. 22. Chap. 2. Book 1. and by Prob. 10. Chap. 3. Book 2.

5. Add the sum of this Surface to the sum of the two Heads; then multiply the half of all these added together, by the length of the Barrel: this will give you the Capacity.

CHAP.

CHAP. VI.

Of Tranſmutation.

TRanſmutation is a Science which teaches us to encreaſe or diminiſh any given Figures, or to give them another form. We ought to take notice, that what is here ſaid of Figures, may alſo be underſtood of Bodies, when one would give them another ſhape which they had not before: But ſince we produ'd ſomewhat of this matter in Chap. 2. Book. 1. from Prob. 21. to the end of the Chapter, we ſhall at preſent only treat of the Tranſmutation of Bodies.

PROBLEMS.

I. *To turn a Cylinder into a Parallelepiped of the ſame height.*

1. Inſtead of the Baſe of the Cylinder C B A, make a Square A B C D, by Prob. 23. Chap. 1. Book 1.

2. Raiſe upon A B C D four Perpendiculars of the height of A B, which may repreſent

ſent the height of the Cylinder, as E F G H.

3. Joyn E F, E H, F G, and G H together by right lines; and you have the Parallelepiped.

II. *To turn a Cone into a Pyramid of the ſame height.*

1. Make a Triangle, Square, Pentagon, or what other Polygon you pleaſe, equal to the Baſe of the Cone C B D, and let it be the Baſe of a Pyramid, as A B C D.

2. Raiſe from the middle of the Baſe F a Perpendicular, of the height of the Cone B A, as F E; then draw from A B C D lines to the point, and the Pyramid is made.

III. *To turn a Parallelepiped into a Cylinder.*

Make a Circle equal to the Baſe of the Parallelepiped, and raiſe this Circle to be as high as the Parallelepiped, and the work is done.

IV. *To*

IV. *To turn a Pyramid into a Cone.*

1. Make a Circle equal to the Baſe of the Pyramid.

2. Raiſe upon its Center a Perpendicular as high as the Pyramid, as B A.

3. Draw the extremities of the Diameter C D together till they meet at the top of the Perpendicular A, and the Cone will be finiſhed.

V. *To turn a Priſm or a Cylinder into a Pyramid or a Cone of the ſame height, or the contrary.*

1. Enlarge the Baſe of the Cylinder three times as much as it is, by Prob. 1. Chap. 2. Book 1.

2. Upon its Center raiſe a Perpendicular as high as the Cylinder, and draw the extremities of the Diameter together to the top of the Perpendicular, and the Pyramid will be made: In like manner you may turn a Cylinder or a Priſm into a Cone: On the contrary, when you would make a Priſm or a Cylinder equal to a Pyramid or a Cone, you muſt make the Baſe of the Pyramid or of the Cone three times leſs, and then

then upon this Baſe erect a Cone or Pyramid of the height of the Priſm or Cylinder given.

VI. *To make a Cube equal to a Parallelepiped.*

1. If the Baſe of the Parallelepiped be ſquare, find a mean proportional between its height and one ſide of the Baſe; this mean proportional will be the true meaſure of the Cube required.

2. If the Baſe be only a Parallelogram, turn it into a Square by Prob. 25. Chap. 2. Book 1. then go on as at firſt, and your work will be done.

VII. *To make a Cube equal to a Cylinder given.*

1. Make a Parallelepiped equal to a Cylinder given, by Problem 1. of this Chapter.

2. Afterwards make a Cube equal to that Parallelepiped, by the precedent Problem, and you have the Cube deſired.

VIII. *To*

VIII. *To make a Cube equal to a given Cone.*

1. Make a Parallelepiped equal to a given Cone, by Problem 5. of this Chapter.

2. Afterwards make a Cube equal to that Parallelepiped by Problem 6. of this Chapter.

IX. *To make a Cube equal to a Pyramid.*

This Problem must be wrought like the last foregoing.

X. *To make a Cone equal to a Globe.*

1. Take one of the great Circles of your Globe, and make it four times bigger, by Prob. 11. Book 1. Chap. 2.

2. Raise a Cone upon this Base as high as the Semi-diameter of the Globe A B.

3. The Cone C D E will be equal to the Globe A B D.

XI. *To*

XI. *To make a Cube equal to a given Globe.*

1. Make a Cone equal to a Globe, by the foregoing Problem.

2. Make a Parallelepiped equal to this Cone, by Prob. 5. of this Chapter.

3. Laſtly, make a Cube equal to this Parallelepiped, by Prob. 6. of the ſame Chapter.

Here we conclude our Treatiſe of Geometry, being perſwaded, that the things which we have ſaid, will be enough for thoſe who would make any Progreſs in Fortification.

F I N I S.

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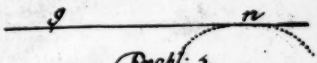

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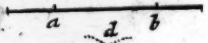

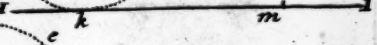

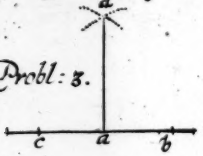

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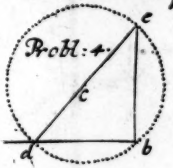

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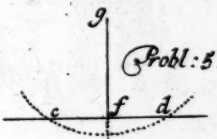

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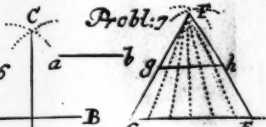

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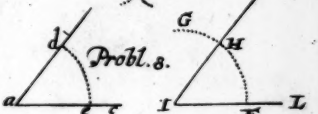

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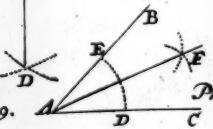

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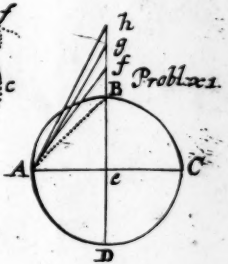

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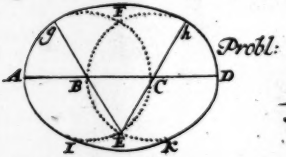

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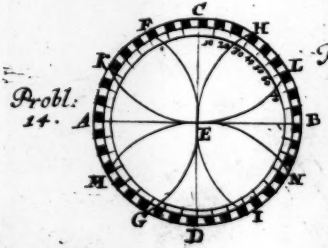

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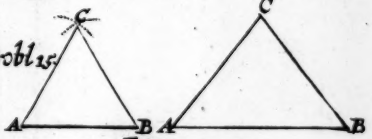

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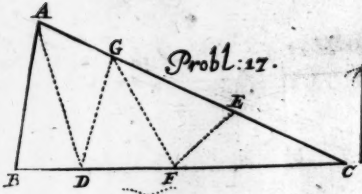

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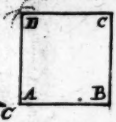

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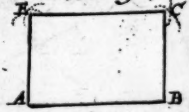

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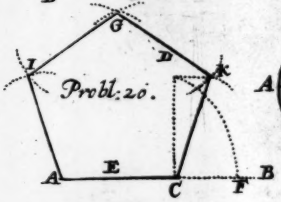

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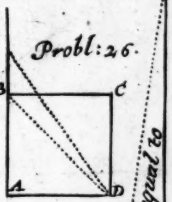

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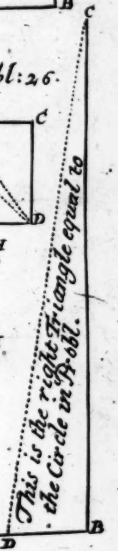

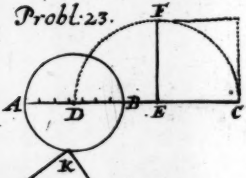

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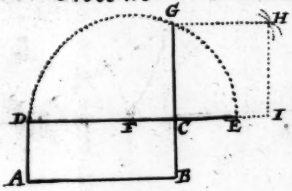

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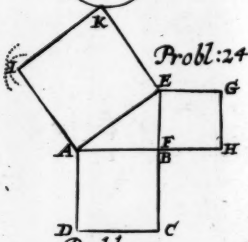

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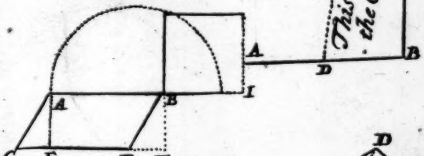

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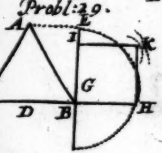

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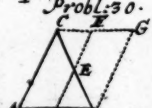

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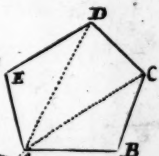

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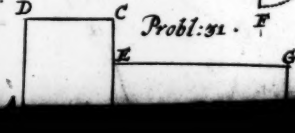

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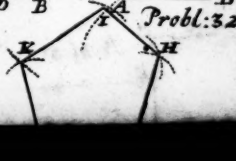

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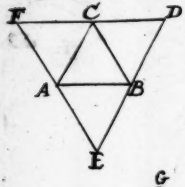

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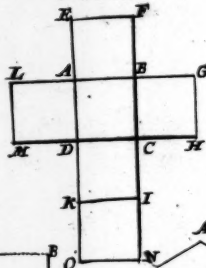

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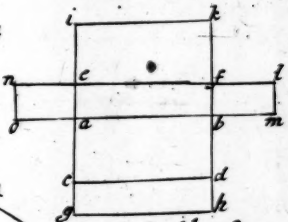

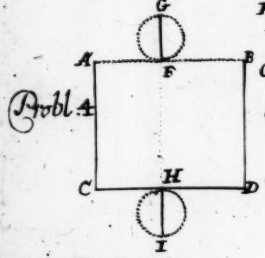

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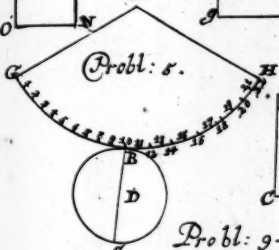

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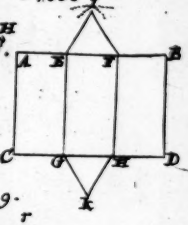

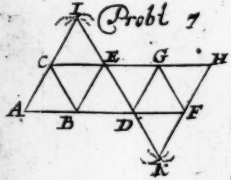

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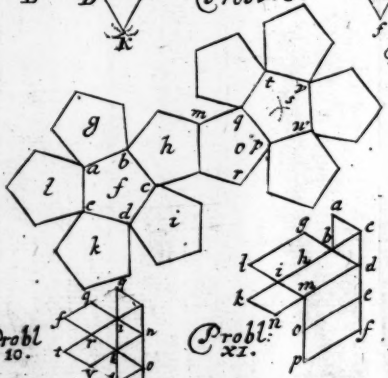

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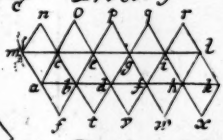

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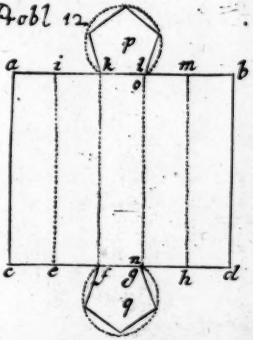

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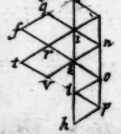

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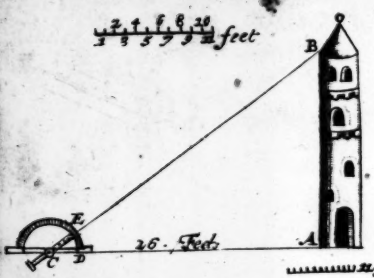

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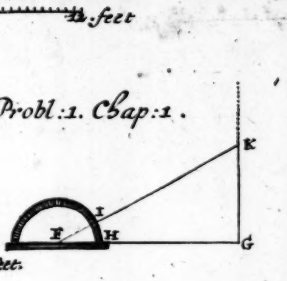

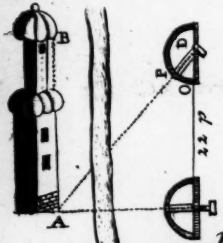

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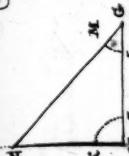

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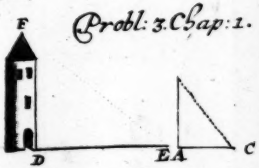

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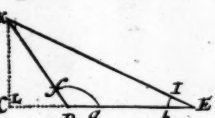

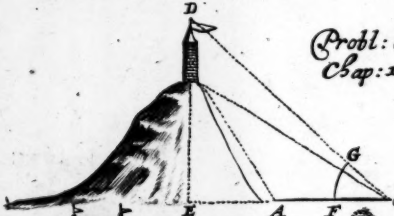

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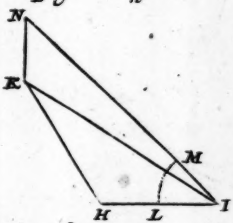

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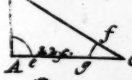

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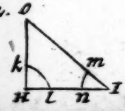

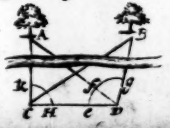

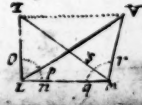

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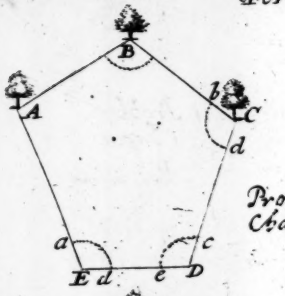

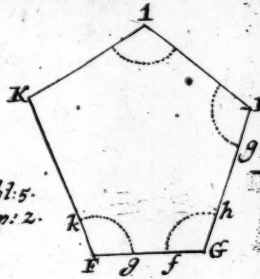

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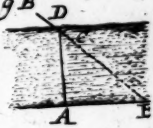

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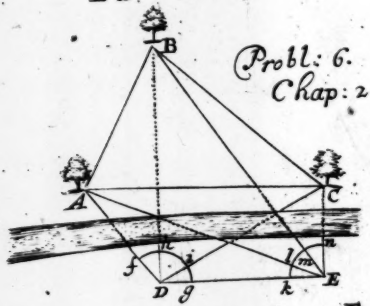

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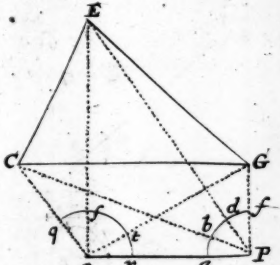

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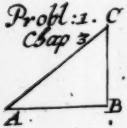

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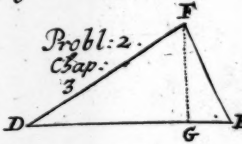

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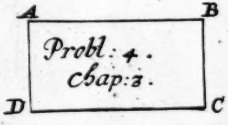

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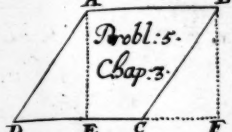

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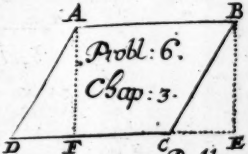

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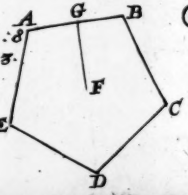

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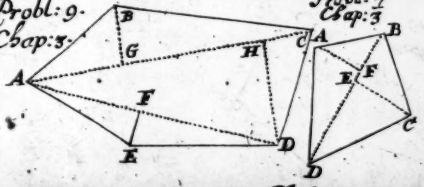

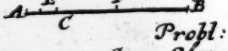

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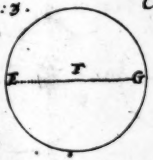

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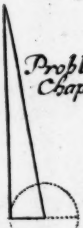

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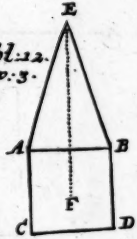

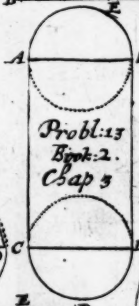

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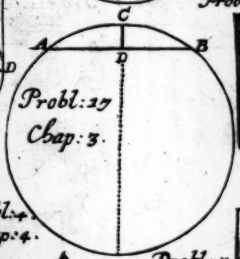

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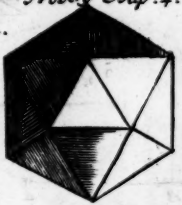

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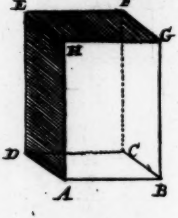

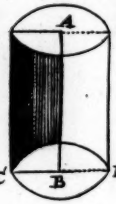

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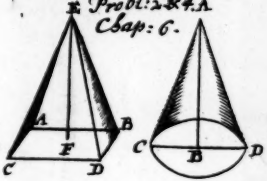

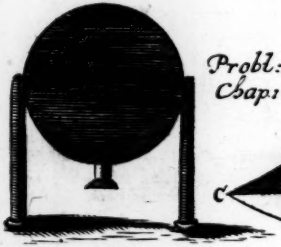

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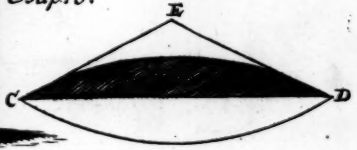

Edw.d Gyles 1757

A NEW TREATISE OF Fortification.

BOOK I.

CHAP. I. Sect. 1.

Of the Definition of Military Architecture.

Fortification, or Military Architecture, is no other thing than an Art, which teaches Men to fortifie themselves with Ramparts, Parapets, Moats, Covert Ways and *Glacis's*, to the end the Enemy may not be able to attack such a part without great loss of his Men; and that the small Number of Soldiers which defend the Place may be able to hold out for some time.

Sect. 2.

Of the Original of Fortification.

CErtain it is, that Fortification was Originally very inconsiderable; for in regard that Men had nothing to fear at that time but the Assaults of Wild Beasts, and Robbers they had no other Fortifications than simple Hedges, which continued still in use 328 Years before our Saviour; at what time *Alexander* the Great found the *Hircanians* and *Mardians* fortified after that manner, *Q. Curtius, l. 6. c. 5.* Afterwards they fortified themselves with Walls, those Hedges being easie to be cut down. But Ambition increasing, in regard that they who covered Dominion over others, soon found a way to leap over these feeble Defences, they added a Moat, and in making this they raised at the same time a Rampart, behind which the Besieged placed himself, to dispierce the Enemy with their Arrows. The Enemy, not able to surmount these Obstacles, resolved to venture some Arrows, to pass the Moat, and lodge himself at the Foot of the Wall, whence the Besieged could not chace him, notwithstanding the great Number of Stones which they threw down to annoy the Assailants, because the Enemies covered themselves with their Bucklers which they held over their Heads. This obliged those within to make Holes in the Walls, by shooting their Arrows at the Enemy, to hinder him from attacking them. For which way soever he came, the *Arbalesta* annoyed him. Nevertheless the Foot of the Walls were without defence, so that the Enemy lodging himself between the nearest Holes, they bethought themselves of making square Towers with Holes on every side: For they stood at the Head of the Walls, to hinder the Enemy from lodging between the Holes in the Wall. True it is, that they soon invented certain Engines which we call at this Day Battering Rams, which were strengthened at the Head with a Massie Point of Iron, and so pusht against the Walls of those square Towers, till they brought them to ruine. After which

they

they made Roundels, which were look'd upon as a ſtronger ſort of Fortification, till Powder began to be known in *Europe*. For we find in Hiſtory, that in the Year 1380. under the Reign of *Wenceſlaus*, the Son of *Charles* the IV, a certain *Franciſcan* Monk, whoſe Name was *Berthold Schwartz* of *Friburg* in *Briſgau*, ſhewed the firſt uſe of Powder to the *Venetians*, then at War with the *Genoeſes*. After which they made Cannon to batter Places, the furious execution of which, ranvers'd like a Clap of Thunder thoſe feeble Walls; which obliged them that were attack'd with theſe aſtoniſhing Engines, to erect a good Rampart behind their Walls, and to make the ſame Walls much thicker than before.

This Manner of Fortifieation would have ſubſiſted a long time, had it not had one defect; which was, that thoſe Round Towers had one part in the form of a Triangle, which could not be ſeen by thoſe within; and which the Enemy coveted to batter, on purpoſe that he might lodge himſelf ſecure from the Shot of the Beſieged, who could not ſee him in that part. To correct this default, they fill'd that defective part with good Earth, which being environed with a good Wall, form'd alſo two Points which look'd toward the Field, as now the Faces of a Baſtion, and which covered that part. The Enemy ſeeing that, began to attack thoſe two Faces before any other thing: So that the Beſieged found themſelves obliged to add Flanks to thoſe Faces, to plant Cannon upon them, and prevent the Enemy from doing ſo much Miſchief to the Faces as before. And thus the Baſtions were invented, as we ſee them at this Day built upon the Angle of the Gorge.

Sect. 3.

Of the Parts of Fortification.

THere are three Parts of it; that is to ſay, *Ichnography*, *Orthography*, and *Sceenography*.

Ichnography is no other than what we call the Plane, or Repreſentation of the Length and Breadth of a Fortreſs.

of which the Parts are marked out either upon the Ground, or upon Paper.

Orthography is called the Profil, or the Representation of a Fortress made and raised, so that a Man may see the Length, the Breadth, and Heighth of its Parts.

Scenography is the Perspective of the Parts of a Fortress.

Sect. 4.

Of the Division of Military Architecture.

FOrtification is Regular or Irregular:

Regular is that where all the Sides, and all the Angles that compose it, are equal one to another.

Irregular is that where all the Sides and Angles are not all equal nor uniform one to another. And it is either Durable or Temporary.

Durable, is that which is built to continue a long time.

Temporary, is that which is erected in case of necessity for a little time: And under this Signification are contained all sort of Works erected for the seizing upon a Passage, or some Hill, or when they make Circumvallations, and Countervallations; that is to say, Redoubts, Trenches and Batteries.

CHAP. II.

Of the Parts of a Fortress, and its Angles.

THE *Curtin*, see Chap. 4. under C.

The *Flank*, see Chap. 4. under F.

The *Face*, see Chap. 4. under F.

The

The Face prolong'd, is the rest of the Flanking Line, after you have taken away the Face.

The Flank prolong'd, is the Prolonging of the Flank to the Exteriour Sides.

The Demi-Gorge, see Chap. 4. under D.

The Capital Line, see Chap. 4. under L.

The Line of Defence is made High and Razing. See Chap. 4. under L.

The Complement of the Curtin, see Chap. 4. under C.

The Distance of the Polygons, see Chap. 4. under D.

The Half-Distance of the Polygons, see Chap. 4. under D.

The Interiour Side of the Polygons, see Chap. 4. under C.

The Exteriour Side of the Polygons, see Chap. 4. under C.

The Small Diameter, see Chap. 4. under P.

The Great Diameter, see Chap. 4. under G.

See the Plan representing all these Parts.

Of the Angles.

THE Angle of the Center, or Angle of the Figure, is that which is made by drawing Right Lines from the Center to the two meanest Angles of the Polygon.

The Angle of the Circumference, is the mixt Angle which is made by the Arch, which is drawn from one Gorge to the other.

The Flank'd Angle, is the Angle compos'd of two Faces.

The Flanking Angle, is the Angle compos'd of the Line of Defence, and the Curtin.

The Angle of Complement of the Line of Defence, is the Angle which is made of the two Complements, where they inter-cut one another.

The Angle Form-Flank, is the Angle which is compos'd of one Flank and one Demi-Gorge.

The Angle Form-Face, is that which is compos'd by one Flank and one Face.

The Angle of the Moat, is that which is made before the Curtin, where it cuts it self.

The Re-entring Angle, is that which retires inward.

The Saliant Angle, is that which advances toward the Field.

See the Plate A.

CHAP. III.

Of the Terms of the Measures.

A Rod, is the length of 12 Geometrical Feet, and is made use of in *Germany* and *Holland*.

A Fadom, is the length of six Geometrical Feet, of which they make use in *France*.

A Geometrical Pace, is the distance of five Geometrical Feet.

The Simple Pace, is the distance of three Geometrical Feet.

The Cubit, is the length of one Foot and a half.

The Geometrical Foot, is the distance of 12 Thumbs breadth.

A Thumbs breadth, is the length of 12 Lines, of which the one is a Barley-Corn's distance from the other.

A German League, is the space of 4000 Geometrical Paces.

An Italian League, is the space of 1000 Geometrical Paces.

A Simple French League, is the space of 1000 Geometrical Paces.

A Common League, is the space of 2000 Geometrical Paces.

A Furlong, is the space of 125 Geometrical Paces, of which they make use in *Greece*.

A Parasangue, is the distance of 30 Furlongs, or 3750 Geometrical Paces, made use of in *Persia*.

The Simple Schœnus or Cord, is the distance of 30 Furlongs among the *Egyptians*.

The Compound Schœnus, is the distance of 60 Furlongs in *Egypt*.

CHAP.

CHAP. IV.

Of the Names and Terms made use of as well in Attacking, as in the Defence of Places, Alphabetically set down.

A.

Wings, are the large Sides which terminate and bound to the Right and Left the Exteriour Works, as the Horn and Crown-Work, *&c.*

Wings of Armies, are the Regiments posted upon the Right and Left Hand, when the Army is drawn up in Battalia.

Antestatwe, is a small Retrenchment made of Gabions, to possess the remainder of the Grand Attack.

Approaches, are all sorts of Advantages, by the Assistance of which we advance toward a Place besieged.

Arriere-Gard, is that part of the Army which marches after the Main Battel, to hinder and stop Deserters.

Arsenal, is a place appointed for the forming and preservation of every thing that is necessary for Defence and Assault.

Artillery, is all sort of Fire-Arms.

Assault, is an Attack made upon a Fortress, to win it by main force.

Attack, is an Effort made by the Besiegers, to approach the Walls of a Fortress.

False Attack, is an Effort to the same end, but more remiss, to oblige the Besieged to divide their Forces.

To Attack in Flank, is to attack both sides of the Bastion.

B.

Bacule, is a Gate that is made like a Pit-fall, with a Counterpoise, before the Corps *de Gards* advanced near the Gates, and which is supported by two great Stakes; a Portcullice,

Banquette, a little Foot-pace at the bottom of the Parapet, upon which the Soldiers get up to fire into the Moat, or upon the covert way.

Barricadoes, are Trees cut with six Faces, crossed with Battoons as long as a Half-Pike, bound about with Iron at the feet, and set up in Passages or Breaches to keep back as well the Horse as Foot.

Barriers, are great Stakes planted 10 Foot one from another, about four or five Foot high, with their Transoms or overthwart Rafters, to stop those that would enter with Violence; and where they cry to every Body that shew themselves, *Whence come ye?*

Bastion, is a Heap of Earth usually rais'd upon the Angle of the Gorge, compos'd of two Flanks and two Faces.

Flat Bastion, is that which is rais'd upon the Curtin, when it is too long to be defended by the Bastions on each side.

Battalion, are several Foot-Soldiers rang'd in Battalia: It is compos'd of two Marches of Musqueteers, and a Center of Pikemen.

Battery, is a place rais'd, whereon to plant the Great Guns, and play upon the Enemy.

Berme, is a little space of four or five Foot, left at the foot of the Rampart without, to prevent the Earth from falling into the Moat.

Blinds, are pieces of Wood set a-cross upon the Trenches to sustain the Bavins or Hurdles laden with Earth, which are to cover the Trench.

Red Bullets, are Bullets made red hot in a Forge, with which the Cannon are charg'd to set Fire upon Houses or Magazines.

Boyau, is a Moat border'd with a Parapet, which is drawn from one Trench to another for better Communication.

Breach, is the Ruine which the Cannon or a Mine makes in a Fortification to take it by Assault.

Brisure, is a Line from four to five Fathom, which is allow'd to the Curtin and Orillon to make the hollow Tower, or to cover the conceal'd Flank.

A Bomb,

C.

A Bomb-Chest, is a kind of a Woodden Chest wherein are put from three to six Bombs, which is placed under Ground, to blow it up into the Air, in case it be taken.

Camp Flying, is a small Body of an Army which keeps the Field, to prevent the Incursions of the Enemy, harrass the Country, hinder Convoys, and to throw it self into any besieged Place.

Caponiere, is a hollow Lodgment of about four or five Foot, border'd with a little Parapet of above two Foot high, to hold Planks laden with Earth; there are little Embrasures sometimes made in 'em, which are called Murdresses. This Lodgment is wide enough to contain 20 or 30 Soldiers, and is usually placed upon the Extremity of the Counterscarp.

Carcasse, is an Artificial Fire, compos'd of from three to four Granadoes, with several Barrels of Pistolets charg'd, and wrapt up in Tow, dipt in Oyly Substances, with a pitch'd Cloath round about it; All which is put in a kind of Lanthorn, which has a thin Plate of Iron at each end, held fast by two Branches of Iron, which are cross'd by Circles of the same Matter; and in one of these thin Plates there is a hole to fire the Carcass, which is afterwards forced into the Air like a Bomb.

Cartouche, is a Roll wherein the Charge of the Cannon is put, which besides the Powder consists of several Chain-Rings, ends of Pistols, Bullets, Heads of Cart-Nails, and and other Iron Materials: And the Cannon conceal'd in the retired Flanks is usually charg'd with such Cartouches to make the more Havock.

Cascans, are certain Wells, some more hollow than others, which are made in the Retrenchment of the Platform near the Wall, to give Air to a Mine.

Casemate, is a certain Vault made in a part of the Flank which is next the Curtin, all of Masons Work; it is made to fire upon the Enemy, and defend the face of the opposite Bastion, and the Moat.

Cavalier, is a mass of Earth raised in a Fortress, to lodge the

the Cannon, to scoure the Field, or oppose a commanding Work.

Chandeliers, are wooden Parapets covered with Bavins, filled with Earth about a Foot high, made use of in Approaches, Mines and Galleries to cover the Workmen, and hinder the Besieged from constraining them to quit their labour.

Chausses Trappes or *Caltrops*, are Irons with four Spikes about four Inches long, so disposed, that which way soever they fall, one Point still lyes uppermost; they are made use of to throw into Moats and Breaches, to stop the hasty coming on of the Enemy.

Covert Way, is a Walk round about the Moat towards the Country, having a Foot-pace and the Glacis for a Parapet.

The Chemin de Ronde, is a Walk between the Rampart and the Wall.

The Shirt or *Chemise*, is the Solidity of the Wall from the Talus to the Stone Row.

Chevaux, or *Freisland Horses*, so call'd, because first made use of at *Groningen*, a City of *Freisland*, are great pieces of Wood with six Sides, driven through Piles or Stakes of Wood armed with Iron, to hinder the Horse and Foot from going forward.

Circumvallation, is a Moat bordered with a Paraper, which flanks it self from distance to distance, sunk about the Besiegers Camp, as well to hinder the Relief of the Besieged, as to stop Deserters.

Clayes, are Twigs interwoven together, having the Figure of a long Square; they are plac'd upon an Allodgment, and cover'd with Earth; and sometimes they are laid upon marshy Ground to consolidate it.

Coffer, is a hollow'd depth from 6 to 7 foot, and broad from 16 to 18, all athwart a dry Moat: Upon the upper part of this they place a Parapet, and a Crosis, pieces of Wood, cover'd with Clayes loaden with Earth.

Commandment, is a height of 9 foot which one place has above another.

Complement of the Curtin, is the remainder of the Curtin, after

after you have taken away its Flank, to the Angle of the Gorge.

Complement of the Line of Defence, is the remainder of the Line of Defence, after you have taken away the Angle of the Flank.

Counter-Approaches, are Works which the Besieged make to hinder the Approaches of the Enemy.

Counterscarp, is properly the declining of the Moat on that side next the Country; although by this term is understood, the Covert-way with its Parapet.

Counter-Forts, are certain Pillars and Parts of the Walls, distant from 15 to 20 foot one from another, which advance themselves as much as may be in the Ground, and joyn themselves to the height of the Cordon, by Vaults, to sustain the Chemin de Rondes, and part of the Rampart, to fortifie the Wall, and strengthen the Ground.

Counter-Gards, are Triangular Pieces, in form of a large Parapet, which raise themselves above the Moat before the Faces and the Point of the Bastion to preserve them.

Countermine, is a Subterraneal Way which the Besieged makes in search of the Enemies Mine, to take away the Powder, and frustrate the effect of it, though fir'd by the Assailant.

Countervallation, is a Moat guarded with a Parapet, which the Besiegers make to secure themselves from the Sallies of the Garison.

Corbeills, are a sort of Gabions fill'd with Earth, plac'd upon the Parapet to fire upon the Enemy, without being seen by them.

Cordon, is a row of Stones made round, which is plac'd where the Wall ends, and the Parapet begins; and it runs round about the place.

Coridor, is the Covert way above the Counterscarp, round about the place, between the Moat and the Palisadoes.

Cornes or *Horns*, are Outworks which advance toward the Field, and carry in the fore part two half Bastions in the form of Horns, which they present to the Enemy.

Crowning, is a Work drawn beyond the Horns to keep the Enemy at a distance.

Curtin, is the longest streight Line that runs about the Ram-

Rampart drawn from one Flank to the other, and border'd with a good Parapet 5 foot high, behind which the Soldiers place themselves to fire upon the Covert way, and into the Moat.

Cuvette, a little Moat about 4 fathom broad, which is usually sunk in the middle of a great dry Moat, till you meet with Water. It is good to prevent the Besiegers Mining.

D.

Defenses, are all sorts of Works that flank one another, and which the Enemy desires to ruin, before he strive to pass the Moat.

Desile, is a streight narrow passage, through which there is no marching but in file.

Dehors, are all sorts of separate Outworks, as Rawlins, Half-Moons, Hornworks, Crownworks, Counterguards, Tenailles, &c. the better to secure the main Place.

Demi-distance of Polygons, is the distance between the Exterious Polygons and the Flanks.

Demi-gorge, is a Line drawn from the Flank to the Angle of the Polygon.

Demi-lune, is a small flank'd Bastion, plac'd before the Point of a Bastion, when it is too weak; sometimes this Work is plac'd before the Curtin, when the Moat is a little wider than it ought to be.

Descent into the Moat, is a deep digging into the Earth of the Covert way, in form of a Trench, of which the upper part is cover'd against Artificial Fires, to secure the descent into the Moat.

Distance of Polygons, is the Line compos'd from the Flank and its Prolongation, to the Exterior Polygon.

Donjon, is a Place of Retreat, to Capitulate with more advantage in case of necessity.

E.

Embrasure, the Hole through which the Great Guns are discharged.

Embuscade, the Place where the Souldiers hide themselves to surprise the Enemy.

Enceinte,

Enceinte, the Circumference of a Place, sometimes lin'd, and compos'd of Bastions and Curtins, sometimes not.

Esplanade, is the place void of Houses, between the Citadel and the Town.

F.

Face, is the most advanced part of the Bastion toward the Field, and is the first Attack'd.

Fascins, are Bavins of small Wood, two Foot broad, and four long, bound about at the ends and middle, thrown into Moats where there is much Water, to facilitate the passage over to the Wall.

Fals Braye, is a small Rampart four Fathom wide, border'd with a Parapet, and a Banquet, running round about the Body of the Place. It is made use of to Fire upon the Enemy, when he is already so far advanc'd, that you cannot force him back from off the Parapet of the Body of the Place; or else, to receive the Ruins which the Cannon make in the Body of the Place.

Flank, is the part which joyns the Curtin to the Face of the Bastion, from which the Face of the next Bastion requires its Defence.

Flank Covert, is that, the exteriour part of which advances to secure the innermost; which advanced part, if it be rounded, is called an *Orillon*.

Flank Fichant, that which plays, and fixes its Bullets in a direct Line in the Face of the adjoyning Bastion.

Flank Rasant, is that, from the Conjunction of which with the Curtin, the shot razes the Face of the next Bastion; which happens when the Face cannot be discovered but from the Flank alone.

To Flank a Place, is to play upon a place in such a manner, that there shall be no part of it but what is Defended; and from which you may play upon the Enemy both in Front and Rear, and so oblige him to retire.

Forts of the Field, or *Fortins*, are all Fortresses, whose Flank'd Angles are distant one from another 120 Fathom. They are only for a time to guard some Passage, or dangerous Place; or else they are used in Circumvallation.

Fougade, is a small Mine made under the Ground, which

which the Enemy would blow up. It is furnished with some Sacks of Powder, to which the Sawcedge is fix'd, which answers to another Post, to the end it may be Fir'd without danger.

Fraises, are pieces of Wood from 7 to 8 Foot long, driven in almost half way into the Earth of the Rampart without side, and a little below the Parapet, they present their points somewhat sloping toward the Field; and are made use of to prevent Deserters and Surprizes.

G.

Gabions, are Baskets equally wide at top and bottom, about four Foot in Diameter; they are fill'd with Earth, and usually plac'd upon Batteries and Parapets that have suffer'd very much, and before other places, to secure them from the Enemies Shot.

Gallery, is a cover'd walk, either of Earth or Tuff. The sides of it are made with Planks and Pillars; and they are made use of in the Moat already fill'd with Fagots and Bavins, to the end the Minor may approach safe to the Bastion.

Glacis, is the Parapet of the Covert-way, which looses it self insensibly in the Field. The largest are the best.

Gorge, is the entrance of the Platform of the Bastions and other Works: It never ought to have a Parapet, for fear the Enemy being Master of it, he should secure himself thereby from the shot of the Garison.

Granado, a little hollow Globe fill'd with Powder, to which there answers a little Fusee of Powder, to set them on Fire; they are used to Fire close and narrow Places; or else to disorder the Ranks of the Soldiers.

Grand Demi Diameter, is the Line compos'd of the Capital, and the small Demi-Diameter of the *Polygon*.

Gazons, are peices of fresh Earth, covered with Grass, about a Foot long, and half a Foot thick, cut in the form of a Wedge to line the Parapet, and the Traverses of the Galleries.

H.

Heriſſon, a Beam, with a great quantity of Nails having

ving their points outward; it is supported by a Pivot upon which it turns, to stop up any passage instead of a Barrier.

Herse, is a Lattice, or Portcullice, of great pieces of sharp-pointed Wood at the lower end, sustained by a Cord fastened to a *Moulinet*, which is cut in case of surprize, to the end the Herse may fall, and stop up the Passage of a Gate, or other Entrance of a Fortress.

Horse-Shoe, is a Work sometime round, sometime oval, bordered with a Parapet: It is made to secure a Gate, or to relieve an over-tedious Defence.

L.

Line Capital, is a Line drawn from the Angle of the Gorge to the Angle of the Bastion.

Line Cogrital, is the Line drawn from the Angle of the Center to the Angle of the Bastion.

Line of Defence, is that which is represented by the Discharge of the small Shot, which uncovers the Face of one Bastion by razing it.

Line of Defence Fichant, is the Line drawn from the common Point to the Curtin, and from the Flank to the Flank'd Angle of the Bastion.

Line of Defence Razant, is the Line drawn from the Capital Line of a Bastion, to that part of the Curtin where the Defence begins, to discover the Face of the same Bastion.

Lines of Communication, are the Lines that run from one Work to another, to stop the Fury of the Enemy.

Lines within-side, are the Moats toward the Place under Sallies.

Lines without-side, are the Moats toward the Field to hinder Relief.

Lodgment of an Attack, is a Work cast up in a dangerous Post, to secure themselves against the Enemies Fire: This Lodgment is made of all the Materials that are capable to make Resistance.

To Line, is nothing else but to environ a Rampart, Parapet or Moat with a good Wall or good Turff.

Madrier,

M.

Madrier, is a thick Plank, sufficient to cover the Mouth of a Petard, and which is applyed with the Petard against the Places they would break: This Term is also applied to several Flat Beams which are put at the bottom of a Moat to support the Wall.

Manteller, is one or several Planks joyn'd together, and cover'd with Tin, carried upon two Wheels, which the Pioneers in a Siege drive before them to secure themselves against the small Shot.

Merlon, is that part of the Paparet which is between the two Embrasures.

Mortier, is a piece of great Cannon very short, which is charged with Bombs, Carcasses, or Stones; and is mounted upon a Carriage, the Wheels of which are very low.

Moulinet, is a Cross of Wood, which turns Horizontally upon a wooden Stake, which stands at the side of the *Barrier*, between the Bars of which the Footmen pass.

Moyenau, a sort of small flat Bastions, plac'd in the middle of an over long Curtain, of which the Bastions that are at the Extremities, are not well defended from the small shot by reason of their distance. This Work is proper for the placing in it a Body of Musketiers, to Fire from all sides.

N.

Nailing of Cannon, the driving of a Nail by force into the Touch hole of a great Gun.

O.

Orgues, are thick and long pieces of Wood, hung up over a Gate, every one by a Cord, which answers to the *Moulinet*, that is to be cut in case of a Surprize; and they are to be preferred before *Herse's*.

Orillon, is a small Rounding, which joyning with the hollow Tower, at the end of the Face of the Bastion, covers one part of the Flank.

P.

Palisadoes, are wooden Stakes from 5 to 7 Foot high, arm'd with two or three Iron points, which are fix'd before

fore Fortresses, Curtins, Ramparts, and Glaces: Some there are which are not armed with Iron.

Parapet, is an Elevation of Earth upon the Rampart, behind which the Soldiers stand, and where the Cannon is planted for the defence of the Place.

Park, is a certain Place made choice of in the Camp, out of Cannon-shot of the place Besieged, to plant the Artillery, and to keep the Artificial Fires, Powder, and warlike Ammunition, which is only guarded by Pike-men.

Petard, is a hollow Engin made of Metal, almost in the shape of a Cap, from seven to eight Inches deep, and five Diameter in the Muzzle. It is charg'd with Powder beaten as small as may be, and then fix'd to the *Madrier*.

Petty Demi-Diameter, is the Circumference drawn from the Center through the Gorges.

Place of Arms, is a Piece of Ground sufficient to draw up the Men to be sent from thence as occasion requires.

Place of Arms without, is a Place allowed to the Covert Ways, where they make obtuse Angles, whereon to plant some Pieces of Cannon, or Falcons, to force those that advance in their Approaches to retire.

Place of Arms particular, is a Place near every Bastion, whence the Soldiers sent from the Grand Place to the Quarters assign'd them, relieve those that are either upon the Guard, or in Fight.

Place Irregular, is a Place whose Angles and Sides are unequal.

Place Regular, whose Angles and Sides are every where equal.

Plane, the Representation of a Work in its Heighth and Breadth.

Plat-Form, is the whole Piece of Fortification raised in a re-entring Angle.

Polygon Exterior, is the distance of one point of a Bastion from the point of the other.

Pont de Jonc, is a Bridge made of great Bundles of Bull-rushes, that grow in the Marshes, which are afterwards bound together, upon which they lay Planks, and then lay them in muddy and marshy places to secure their footing.

Pont Flottant, or Floating Bridge, is a Bridge made in form of a Redoubt, composed of two Boats covered with Planks: They ought to be so solidly fram'd, as to bear Horse and Cannon.

Postern, is a false Door, often made at the bottom of the Curtin, or near the Orillon, for private Sallies.

Profil, the Draught of a Work, with all its Length, Breadths and Heighths.

Q.

Quarter of a Siege, is the Incampment upon one of the most principal and important Passages round about the Place besieged, to prevent Relief, and Convoys.

R.

Ravelin, is a small Triangular Work without Flanks, and having no more than its two Faces: It is generally rais'd before the Curtins, where the Moat makes a Saliant Angle.

Redans, Works made in form of the Teeth of a Saw in Re-entring and Saliant Angles, to the end that one part may defend another: They are usually placed upon the Entrances into Rivers.

Redoubt, is a small square Fort, having no defence but in Front. It is usually designed to maintain the Trench, for Circumvallations, and Countervallations; and in Watry Places they are often made of Masons Work for the security of the Neighborhood.

Reduit, an advantageous piece of Ground Entrench'd from the rest of the Place, to retire to in case of surprize.

Rampart, is the raising of the Earth which runs about a Place, composed of Bastions and Curtins, wherein to put the Soldiers, and plant the Cannon for the defence of the Place.

Retirade, an Intrenchment form'd by two Parapets making a Re-entring Angle, which is made in a Work resolved to be disputed Inch by Inch. Sometimes it has a Moat.

Retrench'd

Retrenchment, is a Work made of part of a Rampart, when the Enemy is so far advanced, that he is no longer to be resisted or beaten from the Old Rampart; and to the end that he may not make any New Opposition; it is bordered with a good Parape, and sometimes with Gabions and Bavins laden with Earth.

Rideau, is a small Elevation of Earth in the plain Field, which extends it self in length; very proper for those that would besiege a Place at a near distance, and to secure those that would approach to the Foot of the Place.

Rondel, is a Round Tower sometimes raised at the Foot of the Bastions.

S.

Sack for Earth, a Sack of Course Cloth to contain a Foot, or a Foot and a half; serviceable upon several Occasions, but especially for the making Retrenchments in haste.

To Saignor a Moat, to empty the Water by Subterraneal Conveyances, to pass it the more easily, after you have cast Hurdles upon the Mud that remains.

Sappe, is the deep digging into the Earth of the Covert Way and *Glacis* in the Form of a Trench. The Earth which is thence digged out, serves for security on the Right and Left, and covers you above against the Fireworks by the help of the Hurdles laden with Earth.

A Sarrasins, is no more than a Herse.

Saucidge, is a piece of long Cloth, of which they sow the sides all along in form of a Gut, which they dip in Pitch, and fill with Powder; The largeness of it ought to be so much as to contain a Tennis-Ball; and then they put one end of it to the place where the Mine is, or a Fougade, or Chest of Bombs, and the other end answers to the place where the Engineer stands that sets it on fire.

Saucidges, are Faggots made of great Boughs, bound in the middle and both ends; whose use is the same with that of Bavins.

Shouldring, is nothing but the Orillon.

Scalade, the mounting of the Wall with Ladders.

Scarp. The *Talus*.

Star, a Work with several Faces, composed of Parts, of which the one flanks the other.

Sillon or *Envelop*, a little Rampart covered with its Parapet raised in a very large Moat, the Draught of which Forms Re-entring and Saliant Angles, to the end that the Parts may reciprocally flank each other.

T.

Talut, is that part which is allow'd to Works, whether of Earth or Masonry, the better to support them; and the worse the Earth is, the more the Sloop ought to be.

Tenaille, is a Fortification that has in front a Re-entring Angle, when it has no Flanks; and this is call'd a Simple Tenaille: But if it have Flanks, then it is call'd a Flank'd Tenaille.

Terre-plain, is that part of the Rampart, which is equally level for the Recoil of the Cannon.

Toure Hollow, is a Rounding made of the Remainder of the two Brisures to joyn the Curtain to the Orillon; where the Small-Shot are placed, that they may not be so much exposed to the view of the Enemy.

Trenches, are Moats which the Besiegers make to approach the more securely to the Place attacked. The depth of it ought to be from 6 to 7 Foot; the breadth from 8 to 10. They are so to be carried on, as not to be in view of the Enemy.

Traverse, is a little Moat bordered with a Parapet to the Right and Left, which the Besieger makes quite athwart the Moat of the Place, to pass secure from Flank-Shot, and bring his Miners to the Bastion. This Travers is covered with Hurdles loaden with Earth, for security from the Fire-Works. The only difference between this Work and the Coffer is this, that the one is made by the Besieger, and the other by the Besieged.

V.

Vedette, a Sentinel on Horseback.

A NEW TREATISE OF Fortification,

BOOK II.

CHAP. I.

Of the Maxims of Fortification.

Since it is impossible to build a Fortress, without having considered before-hand what Reasons there are to induce an Enginier to do it after such a manner, that there is no great matter to be objected against it; there are some certain Maxims established, according to which, when a Fortification is raised, there can be but little said against its Advantages to those that are within; as you may easily examine it your self by the following Obser-

I.

All the Parts which are to enclose a space of Ground, ought to be flank'd, that is to say, view'd on every side, that so there may be no shelter about the place where the Enemy may lodge himself, but what may be discovered by those within, not only from the front, but from the sides, and even from behind, if it be possible.

II.

Whatsoever encloses a durable Fortification, must be either Flank, Face, or Curtain, and built after such a manner, that the first Discharges of the Cannon may not be able to pierce its thickness.

III.

Regular Fortification is much to be preferred before that which is Irregular.

IV.

It is impossible to fortify a Triangle after the Regular way, because the Angle of the Gorge is always less by 90 Degrees.

V.

The straighter the Angle of the Center is, the Place is by so much the stronger, and consequently better, because it gains more Sides.

VI.

The Angle of the Bastion must never be greater than 100 Degrees, nor less than 60, for being bigger, the Face cannot be defended as it ought to be, and being less, it

is not able to resist the Injury of the Weather, or the Efforts of the Mines and Cannon. See *Chap.* 1. *Sect.* 4. of *Book IV.*

VII.

The greatest Angles are best to fortify,

VIII.

The Angle of the Curtain ought never to be less than 90 Degrees, nor greater than 110; because, if it be larger, 'tis too much subject to the view of the Enemy. See *Chap.* 1. *Sect.* 5. of *Book IV.*

IX.

The great Demi-Gorges are to be preferred before the small ones, as well because there is more space to retrench in, as because one may make retiring Flanks, which adds very much to the strength of the place,

X.

Great Flanks are best.

XI.

The Face ought to be never less than the half of the Curtain, if it be not in an Irregular Fortification,

XII.

The Faces of the Bastion ought to be defended by the small Shot of the opposite Flanks,

XIII.

The shortest Faces are best, because they are not so subject to be attacked, as when they come out a great way in the Country. See *Chap.* 3. of *Book IV.*

XIV.

The Curtain ought never to be shorter than 60 Fathoms, which is 360 foot English, nor longer than 100, if it be not in an Irregular Fortification.

XV.

The Line of Defence must not be of greater length than 120 or 125 fathoms, because a Musquet can carry no farther to do execution: *Holanus* goes contrary to this Axiom, when he says, that it may be 150 fathoms; and likewise *George Pascha*, who believes it may be 136 fathoms long.

XVI.

The Talut or Level ought by no means to be forced or streightened, but ought to have sloap enough, that the Ground or Earth may settle of itself.

XVII.

Large and deep Trenches are to be preferred before those that are narrow and hollow, or large and less deep, because the Enemy will find more difficulty to get over the first sort. *See Chap.* 10. *of Book I.*

XVIII.

Dry Trenches are to be esteemed before those that are full of Water, especially in great Places, where Sallies, Retreats, and Succors, are necessary.

XIX.

Trenches full of Water, that cannot easily be drained, ought to be preferred before those that are dry in small

For-

Fortresses, where Sallies, Retreats, and Succors, are not so necessary.

XX.

The Outworks ought always to be lower than the Body of the Place, and those that are at the greatest distance ought to be the lowest.

CHAP. II.

Of the Situation of Places.

AS it is very rarely permitted to make choice of that Space of Ground which is to be fortified, but on the contrary the Place is almost always determined, whether we design to repair an old Fortification, or surround any Town with Bastions, and other kind of Works; or whether we are to make ourselves Masters of the Passage of a River, of any Strait Place, or an Eminence, that is of advantage to command the flat Country, or an Island in a River; or of one or more jettings out of Land into the Sea for the making a Port; and lastly, for several other Uses, the recital whereof would be too tedious; It is necessary upon these Accounts to understand what kind of Situations are best for the Erecting a Strong Hold, and to know the Opinions of others concerning this Matter.

I.

What are the Advantages of a Fortress situated upon a Mountain.

(1.) This Fortification is not easily Ruined by Mines.

(2.) The

(2.) The Enemy will be at a great deal of difficulty to bring their Machines to batter down this Fortification.

(3.) Those of the place may discover the Enemy at a great distance, and so hinder them from making their Approaches nearer.

(4.) The Horse or Batteries of the Enemy, which are planted either on plain or rising Ground, can no ways do any damage to this Fortification, it being always lower.

(5.) Upon an Eminence, the Air is always more healthy than in Vallies or lower Places.

(6.) The Enemy will but very rarely be able to take such a Place by Assault.

What are the Disadvantages of a Fortress built upon a Rock.

(1.) They commonly want Water in such a place.

(2.) It is difficult to bring thither Materials, Provisions, and other Ammunition.

(3.) These Fortifications are for the most part not very durable, having only a sandy or gravelly Earth for Foundation.

(4.) Places so situated, are not to be succoured but with great difficulty.

(5.) Such a Place cannot well be defended, because what is done by the Cannon from top to bottom, is but of little consequence.

(6.) Sallies are there very dangerous, especially if they be at any distance from the Counterscarps.

(7.) These Fortifications are almost always Irregular.

Advertisement.

It is to be observed, that these kind of Situations are good for Citadels, Castles, and other small Forts, in order to command the Country thereabouts.

II.

The Advantages of a Marshy or Fenny Situation.

(1.) The Enemy cannot come near it without danger of being lost.
(2.) This Fortification is not easily blown up.
(3.) These Places may be fortified for little Charge.
(4.) They have there no need of a great Garison.

The Disadvantages of a Marshy Situation.

(1.) It is almost impossible to relieve it.
(2.) It must be strengthened with Piles driven in.
(3.) Sallies thence are commonly unsuccessful.
(4.) The Air is there always unhealthy, which is the occasion of frequent Distempers, because the Water there is always corrupted.
(5.) These Places may be attacked without any great loss of Men, provided they stay till the Frosts.

III.

The Advantages of a Place encompassed round with Water.

(1.) It cannot be undermined.
(2.) There is no occasion for any great Works.
(3.) The Enemy cannot always discharge their Cannon with any certainty, because the Water abates much of their force.
(4.) The Besieged may very easily set fire to the Enemies Shipping.
(5.) The Naval Army is too much exposed to the view of the Artillery of the Place.

The

The Disadvantages of a Place surrounded with Water.

(1.) The Enemy may easily stop their Provision, and hinder their Succors.

(2.) Boats alone are sufficient to attack such a place, and so there is no occasion for Horse.

(3.) These Places are more subject to Diseases than others.

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We may affirm, that these Places that are encompassed all round with Water, which cannot be quite drained, or at least with great difficulty, are the best notwithstanding, because they are, as it were, fortified by Nature.

IV.

The Advantages of Places situated upon an open Rising Ground.

(1.) There is great Plenty of good Earth.

(2.) They are never there in want of Water.

(3.) Almost all these Places are commonly Regular.

(4.) They have there Earth enough to make Retrenchments, in case the Enemy make their Attacks with great fury.

(5.) The Enemy had need to have two or three Armies, if they would intercept the Provision and Ammunition coming to those of the Place from all Parts.

The Disadvantages of Places erected upon Rising Ground.

(1.) The good Soil that there is about such a Place, serves only for the Enemy to make Retrenchments, Batteries, Approaches, Redoubts, and other Works, from whence they may do great Damage to the Besieged.

(2.) The Enemy may form their Camp, as those of the Place did their Fortification, that is to say, they may give

it

in a Regular Figure, and encompass it with a good Trench and a good Rampart.

(3.) The Ground is very good to make Mines under such a place.

(4.) The Enemy may seize all the Fruits growing about these places.

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These Places however are best, because those of the place will take double the Advantage that the Enemy can have.

V.

The side of a Mountain is a very ill place to fortify, and it must be avoided as much as may be, because the top of the Mountain almost always commands the Place within.

VI.

The Valley is is no good place to fortify, because the Enemy may discover them from the top of the Mountain.

VII.

The Advantages of Places situated on the Sides of any Great River.

(1.) You may bring thither by Water, whatsoever is necessary for Building, and for the Soldiers.

(2.) You may fortify the Circumference after the Regular manner, or at least very near it: The side towards the Water is fortified with small Charge.

(3.) It may be easily Relieved.

(4.) Earth is there very plentiful for repairing the Works, and for making Retrenchments.

(5.) You may there make Sluices to put all the Country thereabouts under Water.

(6.) They never want there any Water.

(7.) The Enemy must have a great many Troops to lay Siege to such a Place, by reason of the distance of the Quarters.

(8.) If

(8.) If it be attacked only by Land, nothing hinders but that the Besieged may pass the River at pleasure, and receive Succors by Boats.

(9.) If it be attacked both by Land and by Water, there must be two great Armies, which will be very Chargeable.

The Disadvantages of Places situated on the Sides of a Great River.

(1.) The River serves the Enemy for transporting whatsoever is necessary for a Siege.

(2.) The Enemy may cast up great heaps of Earth to Command the Place.

(3.) The Enemy may easily shelter themselves from the Firing of the Besieged, having great plenty of Earth.

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Tis not to be denied, but that these Places are to be preferred before any of those that we have now mentioned, in case they are Masters of the Pass, by which the Provision and Ammunition is to come in.

CHAP. III.

Of the Quality of the Earth.

WHen you have once made choice of a Place for the erecting a Fortress, before you Engage yourself in so expensive an undertaking, you must examine the Quality of the Earth, and consider whether it be Good or Bad: For there are very Advantageous Situations, the Earth whereof is good for nothing; and on the contrary, there are Ill Situations that have a very good Soil, but they lie subject to be Commanded after such a rate, that it

it would be great folly to settle there: As may be evident by the following Observations.

Sect. I.

MOuntains commonly have a stony Ground, which is the worst of all, as well because it will not stick together as because the Parapets made thereof are good for nothing: But if you are compelled to fortify in such a place, you must make choice of the best Veins of Earth to make the Parapet, and cause it to be brought from elsewhere. 'Tis true, this sort of Earth is of some advantage, in that the Besiegers will find it difficult to cover themselves in their Approaches for want of good Earth.

Sect. II.

THE Gravelly or Sandy Earth is likewise very bad, by reason that it wants a binding Quality, being always apt to tumble down; when you are forced to make use of this, you must mix some good Earth therewith, or some old Dung, and the Ramparts must be well lined with Stones or Bricks, and the Parapets with Turfs.

Sect. III.

THE Marshy Ground is better than the two former sorts, although generally 'tis not very good, because when it comes to dry, being raised into Ramparts and Parapets, it is subject to fall to pieces; besides, 'tis difficult to find Earth enough about a Marshy place for raising Ramparts, Parapets, and Glacis, of a reasonable height; and moreover, the Foundation of these Works must be always strengthened with Piles. But if there be a necessity of raising Fortifications in these places, it must be during the Heats, that so the Earth may have the greater Consistence.

Sect.

Sect. IV.

THE best kind of Earth for Fortifying, is that which they call Fat or Fertile Ground, because 'tis pliable; and you are not obliged to strengthen the Foundation with Piles, nor to line the Ramparts, unless you will.

CHAP. IV.

Of Provision, and other Necessaries.

SEing a Place cannot be able to endure a long Siege, if it has not wherewithal to make resistance, therefore there must be Provision made of whatsoever is necessary for a Soldier; under which Head is to be understood, Money to pay the Troops, Meal, Corn, Hay, Wine, Beer, Brandy, Butter, Salt, Wood, Powder, Lead, Match, Bullets, Cannon or Great Guns, Musquets, Pikes, Sulphur, Pitch, Brimstone, Palisadoes, *Chevaux de Frise*, Hand-Mills, Horse-Mills, and Wind-Mills, that so, if the Enemy should cut off the Water, they might not be without something to Grind their Corn. A good Commander will take care of all this. An able Physician, Chirurgeon, and Apothecary, are there likewise very necessary. To these there might be added, some other Things requisite, in order to keep the Soldiers in good heart.

A NEW

A NEW TREATISE OF Fortification.

BOOK III.

CHAP. I. Sect. 1.

How to inscribe any Polygon within a Circle given.

THIS Problem is commonly treated of in Geometry; Nevertheless, because it is impossible to work on a Regular Fortification on Paper, without knowing before-hand how to inscribe Regular Figures in a Circle given or taken at pleasure, we shall at present discourse something thereof.

(1.) Divide the Diameter of your Circle given, A. B. into as many equal parts, as you would give sides to your Figure: For example, into Five.

(2.) Draw the Diameter A. B. and make with this distance of points A. B. two Arches to intersect in C.

(3.) Draw from the Point C. through the second Part which is mark'd by the Point E. of the said Diameter, a Right Line, till it touch the Circumference also below the Diameter in H.

(4.) This distance from the Intersection to the first Point A. of the Diameter, will be always one side of the Polygon demanded.

See the Plate B. Fig. 2.

Sect. I.

How to make a Scale.

AS every thing is to be done by a Scale, you must know likewise the manner how it is made, which is as follows.

(1.) Divide a Line into 10 equal parts, and one of these to shew the Feet into 10 others; so one of these last 10 will make the hundredth part of your Line; that is to say, one Fathom of your Scale.

(2.) To make the Scale well, you must divide also one Fathom into six other equal parts, to shew the Feet; for a Fathom is six Geometrical Feet, as have been already said. And by this manner you will have a perfect Scale, for to know all the Breadths, Lengths and Heights.

(3.) When you would make any thing that should be very exact, you must likewise take a Foot, and divide it into 12 other equal parts, and so you will have the Inches; for a Foot contains 12 Inches.

CHAP.

CHAP. II.

How to make the Design of a Square.

IN *France* there are three sorts of Fortifications, the Large, the Middle-fiz'd, and the Small; but at present they never make use but of the Middle-fiz'd: Nevertheless we will first shew the Difference, before we speak of the Middle-fiz'd.

The Square.

The Large Manner.

	Fathoms.	Feet.
(1.) The Semi-diameter	141	
(2.) The Side or Exterior Polygon	200	
(3.) The Perpendicular	27	00
(4.) The Face	60	00
(5.) For the Complement of the Line of Defence take	38	00
(6.) The Flank	22	00
(7.) The Curtin	73	04
(8.) The Line of Defence	141	04

The Middle-fiz'd.

	Fathoms.	Feet.
(1.) The Semi-diameter	127	02
(2.) The Exterior Side	180	00
(3.) The Perpendicular	22	00
(4.) The Face	55	00
(5.) For the Complement of the Line of Defence take	33	00
(6.) The Flank	18	01
(7.) The Curtin	64	04
(8.) The Line of Defence	126	00

The Small.

	Fathoms.	Feet.
(1.) The Semi-diameter	113	01
(2.) The Exterior Side	168	00
(3.) The Perpendicular	21	00
(4.) The Face	45	00
(5.) For the Complement of the Line of Defence take	33	00
(6.) The Flank	18	04
(7.) The Curtin	64	00
(8.) The Line of Defence	115	04

The Explanation of the Middle-siz'd Table.

HAving seen the Difference between these three Manners, we shall only speak of the Middle-siz'd, as being most in use at this Day; and to begin, we will explain the said Middle-siz'd Table.

(1.) Take 127 Fathoms, and two Foot between the Points of the Compass, and make a Circle.

(2.) Take 180 Fathoms, and divide them with the Circle into four equal parts: When they are joyned the one to the other, they are called Exterior Sides or Polygons; as A, B, C, D.

(3.) Divide one of these four Sides into two equal parts with 90 Fathoms; as E, F, G, H.

(4.) Draw from the Points E, F, G, H. streight Lines toward the Center, which are called Perpendiculars; to which must be allowed 22 Fathoms in length, as I, L, M, N.

(5.) Set the Rule to the Capital Points A, B, C, D. and draw streight Lines through the end of the Perpendiculars I, L, M, N. at pleasure.

(6.) Take 35 Fathoms, and place them upon the Lines drawn from the Capital Points, to mark out the length of the Faces, as a, b, c, d, e, f, g, h.

(7.) Take 35 Fathoms, and put them from the Point where the Perpendicular ends, *viz.* from the Points I, L, M, N. upon the Lines that have gone beyond the said Points, to mark

mark out the length that is to be taken for the Complement of the Line of Defence, as J O. J P. L Q. L R. M S. M T. N V. N X.

(8.) Draw the end of the Faces and these Points O P Q R S T V X. which terminate the Complement of the Defence, and you will have the Flanks.

(9.) Then joyn together the Feet of the Flanks, and you will have the Curtins.

To make the Orillon.

MOnsieur *de Vauban* does not leave his Flanks, as Monsieur *Pagan* has done, or as the Dutch and Germans do at this Day; but he conceals one part, the better to cover the Cannon by means of the Orillon: And for that Reason we will shew you his manner of raising it, which is not very difficult.

(1.) Divide the Flank into three equal parts.

(2.) Divide the first of the three into two other equal parts, to joyn from this Middle, the two Extremities of the first part, on the side of the Moat; and this little Rounding makes the Orillon.

To make the Hollow Tower or Flank retir'd.

AS you have seen the Reforming of the first of the three parts, placed upon the Flank, now you shall see another of the two remaining parts, the Form of which you must henceforward call the *Hollow Tower*, the Construcure of which is thus.

(1.) Draw from the Capital Points of the Bastions a small streight Line within side of the Bastion, through the end of the Orillon.

(2.) Put five Fathoms upon this Line which you have drawn, as also upon that which is almost parallel to the lower part of the Curtin. This is called the *Brisure*.

(3.) Take the Extremities of the *Brisure* with the Compass, and with that Distance draw two Arches, which intersect one another toward the Moat, in Figure 8.

(4.) Put the Compass upon that Intersection, and joyn the said Extremities of the *Brisure* together by a crooked Line; and thus you will have the Figure which is made at this Day in *France* in stead of the Flanks, as also the Design of the Entire Square. See under B Fig. 3.

CHAP. III.

Of the Structure of the Body of the Place of the Square.

WE are now to see what Largeness or Breadth is to be allowed to the Ramparts, Parapets, Moats, Covert Ways, and Glacis's of Squares, and after what manner they are to be drawn: Observe then what follows.

	Fathoms.	*Feet.*
(1.) The Base of the Rampart	11	00
(2.) The Base of the Parapet	03	00
(3.) The first Banquet	00	15
(4.) The second Banquet	00	02
(5.) The Moat from 16 to	20	00
(6.) The Covert Way	04	00
(7.) The place of Arms	13	00
(8.) The Glacis	36	00

In case the Ground will give you leave to take more, you may do it.

The Explanation of this Table.

(1.) Take 11 Fathoms, and carry them parallel to the Curtins, Flanks, Faces, Brisures and Hollow Towers, on that side toward the inside of the place, to know after what manner you are to draw the Parallel to the Hollow Tower: Put these 11 Fathoms before; then open your Compasses to the Point from whence you drew your Hollow Tower, and draw from the same Point through the said 11 Fathoms a crooked Line, till it joyns the Base of the Brisure and the Face.

(2.) Take three Fathoms, and carry them in the same manner parallel to the Design, to the end the Basis of the Rampart may be opposite to it, and parallel. But you ought

ought to make this Parapet, or three Fathoms, parallel also to the Orillon, as far as the Brisure: For there it is that the Parapet of the Orillon ought to end. As for the Hollow Towers, put as already has been said, three Fathoms, for that is the breadth of the Parapet, before the Hollow Tower, and open the Compass to the point from which you drew the Hollow Tower, and the Base of its Rampart, to draw from the same point through the three Fathoms put before the Hollow Tower a crooked Line joyning the Parapet of the lower Brisure, and the prolongation of the upper Brisure together; and there, where I touch the said Prolongation, from thence I draw a small Line to the next Brisure.

(3.) Take a Foot and a half, and draw with that distance a Parallel round about the Parapet, toward the Base of the Rampart, which will represent to you the first Banquet; round about which you must draw another Parallel of two Foot to mark out the second.

(4.) To draw the Breadth of the Moat, take from 16 to 20 Fathoms, and draw with that distance a Parallel to the Faces, till they intersect one another before the Curtin. To draw this Parallel round about the point of the Bastion, you must put the Compass of the Overture from 16 to 20 Fathoms upon the said point of the Bastion, and draw a little Rounding from thence to the Parallels of the Faces.

(5.) To mark out the Covert Way, take from four to five Fathoms, and carry a Parallel to the Moat; but set it from a point before the Rounding.

(6.) Where the Covert Way makes a Saliant Angle, for example, in G. put there 10 Fathoms to each side, as G. J. and G. H. and afterwards with 15 Fathoms you shall make points where the 10 Fathoms terminate, and draw from the said Points, in the point of the Intersection, streight Lines; and this is that which is called the place of Arms.

(7.) Take 36 Fathoms, or as much as the Ground will permit, and bring a Parallel round about the Covert Way, and the place of Arms to mark out the Glacis or Parapet of the Covert Way. And thus your Square will be perfectly finished.

CHAP. IV.

Of the Structure of the Half-Moon before the Curtin of the Square.

FRom the Angle of the Moat, or Counterscarp, raise a Perpendicular as long as the Demi-curtin, with its Berisure for the Capital P. Q. Observe that in Polygons the Capital ought to be 45 Fathoms in length.

2. From the point Q. draw a streight Line toward the Orillon of the Bastion, terminating on the side of the Moat in S and D.

3. Take five Fathoms, and put them from S and D upon the Counterscarp, toward the inside of the Half-Moon, as E. F.

4. Put the Rule perpendicularly upon the Curtin of the Body of the place, and erect from the points E. F. two small streight Lines, till they cut the Faces of the Half-Moon, as in V H. and the Lines E V, F H, will make you the Flanks of the Half-Moon.

5. Draw the Base of the Rampart A B, of 8 Fathoms, parallel to the Faces, and the Flanks of the Half-Moon toward the inside, as also the Parapet A C, of 3 Fathoms, the first Banquet of one Foot and a half, the second of 2 Feet.

6. Take 12 Fathoms for the wideness of the Moat, which ought to be drawn parallel to the Faces, but not to the Flanks. You must give it also its Rounding before the Capital Point.

7. The Covert Way, Place of Arms and Glacis are made, as in Chap. 3. L. 2. Sect. 5, 6, 7. See the Plate C.

CHAP. V.

Of the Structure of the Ravelin before the Curtin.

THis Work is done as the Half-Moon, when you allow it no Flanks.

Sect.

Sect. 2.

To make a Ravelin with Lunettes.

HAving rais'd the Ravelin as it ought to be done,

1. Take two parts of the Flank of the Body of the place, and put them at the Angle of the two Moats; that is, from the Moat of the Body of the place and that of the Ravelin, upon the Counterscarp, to mark out the Demi-gorges of the Lunettes, as A B, and A C.

2. Take the Flank of the Body of the place entire, and draw from the point B C, two Arches to cut one another in D, and then joyn B D, and C D, together by a streight Line, to have the Faces of the Lunettes.

3. You draw the Moat of these Lunettes from the half of that of the Body of the place, allowing it also a Rounding.

4. The Base of the Rampart, the Parapets, and the Banquets, is made as for the Ravelin. See the Plate D. Fig. V.

Sect. 3.

To make a Ravelin with Counter-guards.

HAving made the Ravelin alone with its Moat in the same manner as has been set down;

1. Prolong the Faces of the Ravelin above its Moat, and from the Intersection of that Line and of the Moat put upon the Prolongation 30 Fathoms, as A B.

2. Put 15 Fathoms upon the Counterscarp of the Moat of the Body of the Place, placing the Compass in the Angle of the two Moats, as C D.

3. Joyn D B together by a Right Line, which side, and the other A B, must be fortified with a Rampart, Parapet, Banquets, Moat, Covert Way and Glacis, like the Ravelin it self, the Distances of which are also here to be observed.

4. Having

4. Having fixed this Work on the other side of the Ravelin, place a small Reduit at the Head between the two Counter-gards, which are thus to be raised: First, where the Moats of the Counter-gards intersect one another, erect from the same Angle a Perpendicular of 20 fathoms, as E F; then divide the Faces of the Counter-gards into two equal parts, as B G and A G, and from the Capital Point of your Reduit draw a streight Line toward the middle of the Faces, marked by the point G, terminating on the side of the Moat of the Counter-gards in H, and the Line F H will be the Face, which is only to be fortified with a Rampart, Parapet, Moat, Covert-way, and Glacis, if need require. See the Plate *C, Fig. VI.*

Sect. 4.

To make a Ravelin, to be placed at the Entrance into Places.

1. HAving the place for a Ravelin, you must erect a Perpendicular of 12 fathoms from the Angle of the Counterscarp, as A B.

2. You must put at the same Angle 6 Fathoms upon the Counterscarp for Demi-gorges, as A C and A D.

3. Erect upon the points C D Perpendiculars of 4 fathoms for the Flanks.

4. Joynt the Flanks and the Capital together to have the Faces.

5. Draw a Moat round about this Work of 2 fathoms and a half, parallel only to the Faces, and round before the Point. In this little Work is placed a great Corps *du Guard*, the better to guard the Gate and the Bridge, and present the Arms to the Officers.

6. That which is left of the place designed for the Ravelin ought to be joyned together, as if the Corps *du Guard* were not there, and fortified with Ramparts, Parapets, &c. as another Ravelin. See the Plate *D, Fig. VII.*

CHAP.

CHAP. VI.

To make a Horn-work before the Curtin.

1. ERect a Perpendicular from 85 to 88 fathoms at the point of the Ravelin or Half-Moon, as Q G.

2. Draw from the point G to each side an Arch of 60 fathoms.

3. Take from 114 to 118 fathoms, which is most usual, and resect these Arches in E F, at the Angle of the two Counterscarps D R.

4. Joyn E D together by a streight Line, as also F R and F E.

5. Divide the Lines E F into two equal parts, from the middle of which set down a Perpendicular of 20 Fathoms G H.

6. Draw the Faces as for the body of the place; their length is 38 fathoms.

7. For the Complement of the Line of Defence take 11 fathoms 2 feet, which joyn together after the end of the Face and of the Complement, to have the Flanks. Draw the Curtin also.

8. To make the Orillon and the Hollow Tower go the same way as is set down in *Lib.* 3. *Chap.* 2. only that you do not divide the Flank but into two equal parts; Monsieur *de Clermont* would have allowed to the Orillon of the Square two fifth parts of the Flank.

9. The Base of the Rampart is to contain 8 fathoms; that of the Parapet, 3; that of the Moat, 12; that of the Covert-way, 5; the first and second Banquet are to have the same wideness, as has been mentioned above.

The TABLE.

	Fathoms.	*Feet.*
The Capital Q G	88	00
The Wing D E	118	00
The Perpendicular G H	20	00
The Face E L	38	00
The Flank L N	11	02

The

	Fathoms.	*Feet.*
The Complement, &c. H N, H M.	21	03
The Curtin M N	38	05
The Line of Defence E M	84	04
The Base of the Rampart	08	00
The Base of the Parapet	03	00
The first Banquet	00	01½
The second Banquet	00	02
The wideness of the Moat	12	00

To make a Ravelin before these Horns.

1. FRom the Angle of the Moat of the Horns, erect a streight Line of 24 fathom for the Capital O P.

2. From the point B draw right Lines toward the Orillon of the two Bastions of the Horns terminating at the Moat, as O Q, O Q.

3. Draw the Base of the Rampart, and the other distances, as in the working of the Horn-work, only that the Moat ought not to be wider than 8 fathoms, nevertheless it must have its Rounding.

4. The Covert-way, the places of Arms and Glacis are made as in the body of the place. See the Plate C, *c.* 4. *l.* 3.

CHAP. VII.

To make a Horn-work before the Bastion.

1. FRom the point of the Bastion draw a streight Line of 86 fathoms, A B.

2. From the point B draw to each side an Arch of 60 fath.

3. Take from 118 to 120 fathoms, and reflect those two Arches in C D, the Angles where the Moat of the Ravelin throws it self into the Moat of the body of the place, as E F.

4. Joyn E C, C D, and D F together, by streight Lines.

5. Divide the Line C D into two equal parts, from the middle of which draw down a Perpendicular from 18 to 20 fathoms, as B H.

6. Draw the Faces as usually; their length is to be 38 fathoms, as K I; the Complement is 21 fathoms 2 feet, as I N; lastly, all the rest is done as in the Horn-work before the Curtin, the parts of which have the same distance. See the Plate E, *Fig. VIII.*

CHAP.

CHAP. VIII.

To make a Horn-work with Shoulders.

1. PRolong the Flanks towards the Field to the length of the Curtin A B, C D.

2. From B and D draw a Perpendicular of from 25 to 28 Fathoms, as B E, D F.

3. From the Points E F raise other Perpendiculars from 110 to 120 Fathoms, as E G, H F.

4. Joyn G H together by a streight Line, which you shall divide into two equal parts, and from the middle of which you must bring down a Perpendicular of 20 Fathoms, as I K.

5. Draw the Faces as usually, the length of which must be 33 Fathoms.

6. The Complement of the Line of Defence is found, by putting the Compass upon the Extremity of the two Faces, and then keeping one Point of the Compass standing in its place, let the other fall upon the Line of Defence. Which is also to be done on the other side, as L M, N O.

7. L M and N O are drawn together for the Flanks, as also M O for the Curtin.

8. To have the *Orillon*, take two fifth parts of the Flank of this Work; the rest is made as usually in like manner as the hollow Tower, or Flank retired.

9. The Base of the Rampart, &c. ought to have the same wideness as the rest of the Horn-works, and to be drawn parallel as far as the Moat of the Body of the place.

10. The Ravelin before this Work is made, as already has been set down in *Chap.* 6. *Lib.* 3. See the Plate *F, Fig.* IX.

CHAP. IX.

To make a Horn-work with a Crown.

1. Divide the Exterior Polygon of the Horn-work into four equal parts, A B, C D.

2. Take

2. Take three parts of these four, and describe them with an Arch at the Angle of the Moat of the said Work E.

3. From the point E erect a Perpendicular as far as the Arch F.

4. Put the same three parts of the point F upon that Arch, as F G and F H, and joyn F G and F H together by a Right Line.

5. From the Line F G and F H, bring down a Perpendicular of 16 Fathoms, as I K, L M; then draw the Faces as usually, of which let the length be 29 Fathoms.

6. For the Complement of the Line of Defence take 27 Fathoms, and then draw the Flanks and the Curtin as before.

7. Prolong the Faces of the Horns to 27 Fathoms as A N, D O, and joyn G N and H O together by a Right Line.

8. Put 24 Fathoms upon the Wing of the Horn, on the side of the Place, as the points A D, as A P and D Q.

9. From the Points N and O draw streight Lines towards the Points P Q, which terminate on the side of the Moat of the Hornwork in R S.

10. To make the *Orillion*, divide the Flank into two equal parts, of which the one serves for the said *Orillion*, and the other for the Flank retired. You are to observe, that the Flanks which joyn their Faces to the Moat of the Hornwork, are left without an *Orillion* and a retired Flank, as N R, O S.

The Base of the Rampart, &c. and all the other distances, are formed as in the Horn-work. See the Plate F. Fig. XI.

CHAP. X.

To make a Crown-work before the Curtin.

1. FRom the Capital Point of your Ravelin erect a Perpendicular of 100 Fathoms, and if there be no Ravelin, take the Curtin of the body of the Place with the

the *Brisure* to draw two Arches, which cut one the other before the Curtin. From which Point of the Intersection you must do as I have already said concerning the Capital Point of the Ravelin, as A B.

2. Take the same 100 Fathoms, and make an Arch from the point B to each side.

3. Take 113 Fathoms, and reflect those two Arches at the beginning of the Orillon C D and E F.

4. Joyn E B and B F together by right Lines, and draw streight Lines from the points E F towards the Orillons of the place, terminating upon the side of the Moat G H.

5. Divide the Line E B, and the other B F, into two equal parts, from the middle of which bring down Perpendiculars, each from 15 to 16 Fathoms, as I M, I N.

6. You are to draw the Faces as usually, the length of which must be 31 Fathoms, as O P, Q R; the Complements &c. of 16 Fathoms, as S T, V W: The Flanks and Curtin are made, as already has been frequently shewed.

7. Divide the Flank into two equal parts, of which reserve one for the Orillon, and the other for the Flank retir'd.

8. The Base of the Rampart takes up 8 Fathoms, that of the Parapet 3; the first Banquet a Foot and a half, the second 2 Feet; the wideness of the Moats 12 Fathoms; as the Covert-way and Glacis, observe the same breadth as there is round about the body of the place. See the Plate G. *Fig. XI.*

The Table for this Work.

	Fathoms.	Foot.
The Capital Line A B	100	00
The Exterior Sides B E, B F.	100	00
The Wings E C and F D, with their Complements to the Orillons	113	00
The Perpendicular	17	00
The Face	31	00
The Flank	13	03
The Curtin	30	00
The Complement of the Line of Defence	16	00

CHAP.

CHAP. XI.

To make a Corum-work before the Bastion.

1. ERect upon the Capital Line of the Bastion a Perpendicular of 100 Fathoms, as A B.

2. From the point B draw to each side an Arch of 100 Fathoms.

3. Take 92 Fathoms and reflect those Arches at the Concourse of the two Moats, viz. That of the Ravelin, and that of the body of the place, in C D, as E D, F C.

4. Joyn C B, B D, F C, and E D, together by streight Lines.

5. Divide the Lines C B and B D into two equal parts, from the middle of which you shall bring down a Perpendicular of 17 Fathoms.

6. You must draw the Faces as usually, allowing to the length of them 31 Fathoms; to the Complement, &c. 16 Fathoms; to the Flank 13 Fathoms, 3 Feet; to the Curtin 29 Fathoms 3 Feet; to the Base of the Rampart, 8 Fathoms; to the Base of the Parapet, 3 Fathoms; and to the Banquet, Coverd-way, and Glacis as usually. See the Plate *I. Fig XII.*

CHAP. XII.

To make a Ravelin before the Point of a Bastion.

1. PRolong the Parapet of the body of the place above the Moat, so that it may cut it in Q S.

2. From the point of the Bastion erect a streight and perpendicular Line, upon which put 36 Fathoms, beginning at the Moat, as C V for the Capital.

3. Upon the prolongation of the Parapet by the points S Q, put 14 Fathoms for the length of the Flanks, as S T, Q R.

4. Joyn T V, V R, together, and you will have also the Faces.

5. Round about the Faces of the Flanks you shall draw the Base of the Rampart of 8 Fathoms; that of the Parapet 13 Fathoms, and the two Banquets as usually; and the Moat of 12 Fathoms, parallel to the Faces and the Flanks, with its Rounding, before the Capital Point V, and the Flanks T R. See the Plate *I. Fig XIII.*

CHAP.

CHAP. XIII.
To make a Single Tenail.

1. PRolong the Flanks of the Body of the place to 110 Fathoms, as A B C D.

2. Joyn B D together by a right Line; divide it into two equal parts, and let fall from the Middle a Perpendicular of 26 Fathoms, as E F. But you muſt obſerve, that this Line ought not to be longer than 20 or 22 Feet, when there is a Ravelin or a half Moon before the Curtain of the Body of the place.

3. Draw the Extremities of the Wings in the point F. as B F. and D F.

4. Draw the Baſe of the Rampart 8 Fathoms, that of the Parapet 3, the two Banquets as uſually. The Moat 12 Fathoms, the Covert Way and Glacis as for the Body of the place.

The Ravelin before the Work.

1. DIvide the Faces of the Tenaille B F and F D. into two equal parts, and put the half of the one upon the Perpendicular erected upon the Angle of the Counterſcarp, as G F.

2. From the point G, toward the Middle of the ſaid Faces of the Tenaille, draw ſtreight Lines for the Faces of the Ravelin, as G L, and G M.

3. The Diſtances for the Body of the place of the Ravelin are the ſame with thoſe of the Tenaille, only that the [illegible]nging to it is no wider than 8 Fathoms. See the [illegible] Fig. XV.

CAAP. XIV.
To make a double Tenail.

1. PRolong the Flanks of the Body of the place to 110 Fathoms, as A B and C D. and joyn B D together by a right Line.

2. Divide the Line B D into two equal parts, and let fall from the Middle of it a Perpendicular of 26 Fathoms, as E F.

3. From the points B D draw ſtreight Lines in the point F for the Faces, each of which muſt be divided into two equal parts, as B G. D H.

4. Erect a Perpendicular upon the Angle of the Faces of 45 Fathoms, as F J.

5. From the point J. draw the Counter-Faces in the points G H.

6. To the Wings, to the Faces, and Counter-Faces, draw the Baſe of the Rampart parallel of 8 Fathoms, and all the other Diſtances as in the ſingle Tenaille. See the Plate K. Fig. XVI.

CHAP. XV.

To make a Baſtion with Counter-Guards.

FOrmerly they were wont to put theſe Works before the Baſtion, the better to cover them The Structure is this.

1. Draw Lines parallel to the Faces of the Baſtion of 15 Fathoms, terminating upon the Counterſcarp of the Ravelin or Half-Moon, and forming a point before the point of the Baſtion, as A B C.

2. Draw the Baſe of the Rampart to theſe two Faces of 18 Fathoms, as E D. All the other Diſtances are the ſame with thoſe of the Ravelin or Half-Moon. See Plate I. Fig. 14. C. XII. Lib. III.

CHAP. XVI.

Of the Structure of a Pentagon.

	Fathoms.	Feet.
1. The Semi-diameter	153	01
2. The Exterior ſide A B. C D J.	180	02
3. The Perpendicular E F.	25	00
4. The Face A X. T	50	00
5. For the Complement of the Line of Defence F G. take	38	03
6. The Line of Defence G B.	131	03
7. The Flank J G.	22	02
8. The Curtain G H.	73	04

The

The Explication of this Table.

SEe Chap. 2. Book 3. There you shall find all that is necessary for the Structure of a Pentagon; provided you take the Distances prescribed here, for those that are mentioned in the same place. See the Plate F. Fig. 16.

Of the Structure of a Tenaille in the Moat.

TO justifie what has been said above of the Line of Defence, observe this Work, the Structure of which is thus.

1. Put the Rule upon the advanced Flank of the Body of the place, and draw a Parallel to that Flank of from 5 to 6 Fathoms, which touches the Line of Defence before the Orillon in E B.

2. Divide the rest of the Line of Defence from B E. to the neareſt Angle C, into two equal parts, as B F. E G.

3. Take the Distance F G, between the points of the Compass, leaving one upon the point F: Carry the other from the point G upon the Complement of the Line of Defence, mark'd F. Then fix one point of the Compass upon the point G. and carry the other from F. upon the other opposite Complement, mark'd H. Then joyn H F and J G together, to form the Flanks: Do the same for the Curtain H J.

4. Draw the Base of the Rampart of 8 Fathoms to the Faces, and to the Flanks of the Tenaille; and to the Curtain from 4 to 5 Fathoms. Then the Base of the Parapet of 2 Fathoms 3 Feet round about. You shall make the 2 Banquets as usually. See the Plate M. Fig. 16.

CHAP. XVII.

Of the Structure of a Hexagon, and other Polygons.

1.	The Semi-diameter takes up	Fath. 180
2.	The Exterior Polygon	180
3.	The Perpendicular	27
4.	The Face	50
5.	For the Complement of the Line of Defence	38
6.	The Line of Defence	136
7.	The Flank	25
8.	The Curtain	71

The other Distances are equal to those of the Pentagon.

Sect. 2. The Heptagon.

	Fathoms.	Feet.
1. THe Semi-diameter takes up	207	03
2. The Exterior Side	180	00
3. The Perpendicular	27	00
4. The Face	50	00
5. For the Complement, &c.	38	00
6. The Line of Defence	135	03
7. The Flank	24	00
8. The Curtain	72	03

Sect. 3. The Octogon.

	Fathoms.	Feet.
1. THe Semi-diameter	238	01
2. The Exterior Polygon	180	00
3. The Perpendicular	28	00
4. The Face	50	00
5. For the Complement, &c.	28	00
6. The Line of Defence	137	03
7. The Flank	25	04
8. The Curtain	71	04

Sect. 4. The Enneagon.

	Fathoms.	Feet.
1. THe Semi-diameter	263	01
2. The Exterior Polygon	180	00
3. The Perpendicular	32	00
4. The Face	50	00
5. For the Complement, &c.	38	00
6. The Line of Defence	138	00
7. The Flank	29	00
8. The Curtain	70	03

Sect. 5. The Decagon.

	Fathoms.	Feet.
1. THe Semi-diameter	291	03
2. The Exterior Polygon	180	00
3. The Perpendicular	36	00
4. The Face	52	00

6. Fa

5. For the Complement, &c.	38	00
6. The Line of Defence	135	00
7. The Flank	32	00
8. The Curtain	70	00

Sect. 6. *The Hendecagon.*

	Fathoms.	*Feet.*
1. THe Semi-diameter	319	00
2. The Exterior Polygon	180	00
3. The Perpendicular	37	00
4. The Face	152	00
5. For the Complement, &c.	38	00
6. The Line of Defence	135	00
7. The Flank	32	02
8. The Curtain	70	00

Sect. 7. *The Dodecagon.*

	Fathoms.	*Feet.*
1. THe Semi-diameter	347	04
2. The Exterior Polygon	180	00
3. The Perpendicular	42	00
4. The Face	52	00
5. For the Complement, &c.	38	00
6. The Line of Defence	137	00
7. The Flank	37	00
8. The Curtain	69	00

CHAP. XVIII.

To make the Profil.

HAving now treated of the Breadths and Lengths of the parts of a Place, it is requisite to say something of the Heighth of the said parts; or rather after what manner to make the Profil of a Place. To which purpose two things are to be observed,

1. That you erect the Profil of the Exterior Works after the same manner as that of the Body of the principal Place; provided that you apply thereto the Heighths, of

which I shall speak as much as is necessary to be known, whereof the Breadths have been above exhibited.

2. That 10 Fathoms of the Scale of which I make use in delineating the Body of the Place, make but one, when I would make the Profil of the same Place. So that 100 Fathoms which I have applyed to the Body of the Place, for this purpose, afford only a Length of 10 Fathoms.

The Profil of the Body of the Place.

FOr Examples sake, let us make the Profil of a Pentagon; and then observe that which follows.

1. Draw a long streight Line, and there mark 11 Fathoms for the Base of the Rampart, beginning at the Left Hand, as A B.

2. Put 1 Fathom 4 Feet immediately behind the Point A, upon the same Line as A C. This Triangle marks out the Interior *Talus*. And to mark out the Exterior *Talus*, put 1 Fathom immediately before B, as B D. But in the Field you must allow larger *Talus* to the Rampart, according to the Nature of the Ground.

3. Erect upon C D two Perpendiculars, each of which contain 3 Fathoms in height, as C E, D F, and then joyn A E, E F, and F B, by a right Line, and that will afford the heighth of the Rampart with its *Talus*.

4. Put 4 Fathoms of the Point E toward the Right Hand, to mark out the Platform of the Rampart, as E G.

5. Erect upon G a small Perpendicular of a Foot and a half for the heighth of the first Banquet, as G J. Then draw from the point J a Parallel to the heighth of the Rampart a Foot and a half broad, as J H; that is, the breadth of the Banquet. Then set another Perpendicular upon the point H, of the same heighth as H J; and from the point J draw also another Parallel of two Feet broad, as L M, and then you will have both the Banquets.

6. Put 4 Feet immediately behind the point G, as G N, and then upon that point erect a Perpendicular of 8 Feet, as N O; which done, joyn the point M, and the point O together to get the Interior heighth of the Parapet with its *Talus*.

7. Prolong

7. Prolong the Exterior *Talus* B F two Feet farther, as H P, and joyn O P together to have the breadth of the Parapet with its Exterior *Talus*.

8. Put four Feet upon the first Line behind the point B, as B Q; from which point let fall the Perpendicular Q R, of 3 Fathoms, and joyn B R together for the Scarp. Which done, put 20 Fathoms behind the point B, for the breadth of the Moat, as B S, then put two points before the point S, as S T; from whence let fall another Perpendicular of 3 Fathoms, as T V; then joyn V S together to have the Counterscarp of the same R V, and so the Moat will be entirely represented.

10. After this take 36 Fathoms, so far as the Ground will permit, and put them behind the point W, upon the same first Line, as W A, and then joyn them together by a streight Line, to represent the Glacis. After this manner you shall have the Body of the Place according to its Lengths, Breadths, and Heights. See the Plate N. Fig. 17.

The Profil of Exterior Works.

THis Profil is made as the preceeding in respect of the 7 first points, saving only that the Base of the Rampart be no broader than 8 Fathoms, nor the Rampart higher than 14 Feet. As to the 8 point of the Description of the preceeding Profil, the only difference consists in this, that the Moat is not larger here than 12 Fathoms, nor deeper than 2 and a half. All the rest is done as in the preceeding. See the Plate N. Fig. 18.

CHAP. XIX.

How to trace out the Draught of a Fortress in the Field.

AFter you have seen the manner of Fortifying upon Paper, it is requisite for an Engeneer, or any one that would discourse of Fortresses, to understand of

what breadth, height, and depth, their Parts ought to be; whence the one or the other part derives its defence, whether it be necessary to fortify one part more than another; where to attack a Place, and after what manner to frustrate the Enemies design. We shall therefore now shew how to trace out a Fortress in the Field: To which purpose it is necessary to know which are the Angles of Exterior Polygons; being these that follow.

The Angle of the Exterior Polygon.

	Degrees.
The Angle of a Square is of	90
That of a Pentagon of	108
Of a Hexagon of	120
Of a Heptagon of	128
Of an Octogon of	135
Of an Enneagon of	140
Of a Decagon of	144
Of an Hendecagon of	147
Of a Dodecagon of	150

The Explication of this Table.

For Example: If you would trace a Polygon of five Bastions, which is called a Pentagon, of which every Exterior Polygon must have the length of the Line given AB, which is 180 fathoms, then proceed thus:

1. Fix the Baroon, upon which you have your Astrolabe, in the hole that is made by the little Peg B, so that you may see through both the Sights of the Astrolabe, from the Point B, or the place where your Instrument is fixed, the Peg A.

2. Count from the left hand towards the right an Angle of 108 degrees, which is the Angle of the Exterior Polygons, to the Pentagon, (if you make an Hexagon, you take this Angle of 120 degrees, *&c.*) there fix a little Peg, which you may see through the moveable Sights, for Example, C; That done, fix a Cord or a Chain to the Peg B, and

and draw a ſtreight Line toward the Point C, upon which you ſhall then put the length of the firſt Line given A B, as B D.

3. Put the Inſtrument upon the Point D, ſo that through its Diopters or Sights you may ſee the Peg B. Then ſeek by the Rule of the Diopters for the Angle of 108 degrees, and there fix another Peg, which you may ſee through the Diopters, as D E. That done, draw a ſtreight Line from the Point D to the Point E, and then put the length of the Line B D upon the Line D E, as D F.

4. Do this as many times as is requiſite for a Pentagon.

5. Divide the Flank into three equal parts, and the firſt alſo into two others, in the middle of which fix the Peg H. Then faſten the Chain to the Point H, and draw the Rounding, as upon Paper, with the Compaſs: That done, draw the Briſures of 5 fathoms, and make in their Extremities two Arches to cut each other in I. Then fix in the place of the Point I a little Peg, and with the Chain that is faſtened to it, you ſhall draw the Flank retired.

6. To make the Rounding of the Moat, ſet the Peg upon the point of the Baſtion or Ravelin, and with the Chain draw the Rounding. See the Plate O, *Fig. XIX, XX*

CHAP. XX.

To make the Streets in a Fortreſs.

1. DRaw to the Curtains of the place a Parallel of 10 fathoms for the place of Arms near the Rampart.

2. Draw all the Points made of that Line before the Baſtion of the place; for Example, A B C D E.

3. Take the Demi-gorge of the place, or which is better, 30 fathoms, and put them from the Center upon thoſe Lines

Lines A B C D E, as a b c d e: Which distances joyn together likewise by streight Lines.

4. Take 3 fathoms, and put them at the Points A a, towards B b and C c, as F f, G g; which must also be done afterwards with B b, C c, D d, E e, &c.

5. Joyn F f and G g together by Right Lines.

6. Take 8 Fathoms of the Line F f, and divide the rest into three equal parts. Then take one part of the three, and put it at the Points F and G, upon the Lines drawn in the Grand Place of Arms, as F G, G L. Which done, put four fathoms upon the same Lines, after the Points H L, as H M. L N. Lastly, joyn H L and M N together by right Lines.

7. Take the second part of the three first, and put them after M N upon the same Lines, as M O, N P, and joyn the Line O P together. Which done, you shall replace 4 fathoms after the Points O P, as Q R, and then likewise joyn Q R together.

8. Divide each Side, F G, f g, into two equal parts, as S T, and joyn the Lines S T together by a Right Line. Then put 3 fathoms on each side of the Points S T, as S s s, T t t, and draw S T together; and these will form the Streets of your Fortress. See the Plate P, *Fig.* XXI.

A NEW TREATISE OF Fortification.

BOOK IV.

CHAP. I.

Of the Principal Angles of a Fortress.

THIS Book contains the Explication of the Parts of a Fortress, whereof we have already spoken: By which are to be understood, the Cavaliers, the Streets, the Places of Arms, the Counter-Guards, the Magazines, Gates, Back-Doors, Drawbridges, Bridges, and other Things. But we shall first begin to treat of the Angles.

Sect. 1.

Sect. 1.

To find the Angle of the Center of every Regular Fortress.

DIvide the Circumference of the Diameter, which contains 360 Degrees, by the number of the Bastions of your Fortress, and the Product of that Division will make the Overture, or Angle of the Center.

For Example: Let us seek the Angle of the Center of a Pentagon; to which purpose, you must divide 360 Degrees by 5. For in regard our Fortress has no more than five Bastions, a larger Divisor cannot be taken: So that the Product of the Division being 72, we must say, that the Angle of the Center of a Pentagon has 72 Degrees of Overture.

Sect. 2.

To find the Angle of the Gorge, as it is called after Vauban's *manner; or the Angle of Exterior Polygons.*

TO find that Angle, there needs no more than to substract the Angle of the Center of the same Fortress of 180 Degrees, and that which remains makes the Angle of the Gorge. For Example: If you would know the Angle of the Gorge of a Pentagon, you must from 180 Degrees substract 72; for that is the Angle of the Center of a Pentagon: Then observe what remains, which will be 108 Degrees, and say, That the Angle has 108 Degrees of Overture.

180
72
108

Sect. 3.

AS for the Angle of the Bastion, and all the rest, it is impossible to know what their Overtures are, in regard they are not always the same: So that it depends upon the knowledge of the Engineer to make the Flanks, so that they may form a good Angle of the Bastion, according to which almost all the rest take their measures. Consult our Authors upon this matter. Nevertheless we shall here set down the Overtures of the principal Angles after our manner of Fortification.

In

In a Square.

	Degr.	Min.
(1.) The Angle of the Center is	90	00
(2.) The Angle of the Gorge	90	00
(3.) The Angle of the Baſtion	63	00
(4.) The Angle of the Courtin	98	30
(5.) The Angle forming the Flank	81	30
(6.) The Angle forming the Front	112	30
(7.) The flanking Angle	67	30

In a Pentagon.

	Degr.	Min.
(1.) The Angle of the Center is	72	00
(2.) The Angle of the Gorge	108	00
(3.) The Angle of the Baſtion	77	00
(4.) The Angle of the Courtin	101	50
(5.) The Angle forming the Flank	78	10
(6.) The Angle forming the Front	116	00
(7.) The flanking Angle	64	00

In a Hexagon.

	Degr.	Min.
(1.) The Angle of the Center is	60	00
(2.) The Angle of the Gorge	120	00
(3.) The Angle of the Baſtion	87	00
(4.) The Angle of the Courtin.	106	00
(5.) The Angle to form the Flank	74	00
(6.) The Angle to form the Front	121	40
(7.) The flanking Angle	58	20

In a Heptagon.

	Degr.	Min.
(1.) The Angle of the Center is	52	00
(2.) The Angle of the Gorge	128	00
(3.) The Angle of the Baſtion	95	00
(4.) The Angle of the Courtin	102	00
(5.) The Angle to form the Flank	77	30
(6.) The Angle to form the Front	120	00
(7.) The flanking Angle	60	00

In an Octogon.

	Degr.	Min.
(1.) The Angle of the Center	45	00
(2.) The Angle of the Gorge	135	00
(3.) The Angle of the Bastion	100	00
(4.) The Angle of the Courtin	103	00
(5.) The Angle to form the Flank	77	00
(6.) The Angle to form the Front	121	00
(7.) The flanking Angle	59	00

In the Enneagon.

	Degr.	Min.
(1.) The Angle of the Center	40	00
(2.) The Angle of the Gorge	140	00
(3.) The Angle of the Bastion	100	00
(4.) The Angle of the Courtin	106	00
(5.) The Angle to form the Flank	74	00
(6.) The Angle to form the Front	125	00
(7.) The flanking Angle	55	00

In a Decagon.

	Degr.	Min.
(1.) The Angle of the Center	36	00
(2.) The Angle of the Gorge	144	00
(3.) The Angle of the Bastion	100	00
(4.) The Angle of the Courtin	98	00
(5.) The Angle to form the Flank	87	00
(6.) The Angle to form the Front	115	00
(7.) The flanking Angle	65	00

In an Hendecagon.

	Degr.	Min.
(1.) The Angle of the Center	33	00
(2.) The Angle of the Gorge	147	00
(3.) The Angle of the Bastion	100	00
(4.) The Angle of the Courtin	101	00
(5.) The Angle to form the Flank	78	00
(6.) The Angle to form the Front	123	00
(7.) The flanking Angle	57	00

In

In a Dodecagon.

	Deg.	Min.
(1.) The Angle of the Center	30	00
(2.) The Angle of the Gorge	150	00
(3.) The Angle of the Baſtion	100	00
(4.) The Angle of the Courtin	101	30
(5.) The Angle to form the Flank	78	30
(6.) The Angle to form the Front	128	00
(7.) The flanking Angle	52	00

Sect. 4.

Of the Angle of the Baſtions.

THis Angle has occaſioned great Diſputes among the moſt part of the Ancients, who have Treated of Fortification: For ſome were of opinion, that this Angle was to be always acute; others, that it only ought to be ſo in the Hexagon, and that it ought to be Right in Figures of more than 6 Baſtions; and this was the uſual practice of *M. Antoine de Ville.* Others there are who maintain the contrary, and ſay, That the acute Angle is never to be allowed of, but in Figures that are under 6 Baſtions, and that it always ought to be Obtuſe in a Forteſs which exceeds that number. True it is, that the greateſt number have been for the right Angle; and it were a ſort of Ignorance to maintain the contrary. *Monſieur* made choice of this Angle in a Square of 60 degrees, in a Pentagon of 72 deg. in a Hexagon of 80 deg. in a Heptagon of 85 deg. 43 m. in an Octogon to an Hendecagon of 90 deg. *Freitag* made choice of this Angle from a Tetteragon of 65 deg. to a Pentagon of 74 deg. from a Hexagon of 80 deg. to a Heptagon of 84 deg. 17 min. from an Octogon of 87 deg. 30 min. and from an Enneagon to a Dodecagon of 90. But he ſoon altered his opinion, maintaining that this Angle ought to be from a Tetteragon of 60 deg. to a Pentagon of 69; from a Hexagon of 75, to a Heptagon of 79 deg. 17 min. from an Octogon of 82 deg. 30 min. to an Enneagon of 85 deg. to a Decagon of 87 deg. to an Hendecagon of 88 deg. 38 min.

to

to a Dodecagon of 90 deg. *Goldman* makes use of this Angle for a Square of 65 deg. for a Pentagon of 69 deg. for a Hexagon of 75 deg. for a Heptagon of 79 deg. 17 m. for an Octogon of 82 deg. 30 min. for an Enneagon of 85 deg. for a Decagon of 87 deg. for an Hendecagon of 88 deg. 38 min. for a Dodecagon of 90 deg. *Pasche* takes it for a Square of 60 fathoms, and augments it still by five, according as the Polygon gains more of the Side. But they who have been accounted most skilful in the Art of *Fortification*, were always, as I have said, for the Right Angle, thô it be alledged, that in making it Acute, there is room for more Firing from the Curtains; or that in making it Obtuse, it is more capable to withstand the Enemies Batteries, and the Injuries of Time. The reason that kept them so fix'd to this Opinion, was, that in their time they made their Breaches with the Cannon, so that this Angle being Right, it had all the perfection that could be desired; whereas the making it Obtuse, diminished the Capaciousness of the Bastion, and of its Flank; besides, that the same Battery could play upon both Fronts: And by making it Acute, the Point of it was so soon broken by the frequent discharges; more especially, if several Guns played at a Time; besides, that bad Weather more easily ruined that Point. But to speak the truth, we ought to believe, that this Angle, whether Right, Acute, or Obtuse, ought never to trouble our Thoughts, provided it be not less than 60 degrees, nor much more than 100: For the Breaches are now made by Mining, wherein there is no more trouble to carry the Point of a Bastion with an Obtuse Angle, than with an Angle either Right or Acute. Moreover, there is this in it, that Breaches are rarely made in the Point of a Bastion, but in one of the Fronts, to the end, that in passing the Moat the Assailants may not be exposed to more than one Firing; so that provided the Angle be well able to resist the Injuries of Time, it is enough. However, much more than 100 degrees are not to be exceeded, because that being more open, it would require the Capital Line to be short; in which case, the Bastion would not have room sufficient.

Sect.

Sect. 5.

Of the Angle of the Curtain.

ENgineers cannot agree concerning the Overture of the Flank; so that every one orders it according to his Fancy. *Erhard* makes the Flank perpendicular to the Faces of the Bastions; and his Reason is, because the Flanks, being oblique above the Curtain, that is to say, making an acute Angle with it, are much more exposed to the Enemy, and consequently more difficult to be ruin'd, as not being batter'd by the Cannon but very obliquely: But granting that this were so, it is no less a Truth to say, that as they are but little expos'd, so neither do they not survey very far; and it is impossible to make good Embrasures upon a Parapet, ordered after that manner. For to play the Cannon above the Parapet, is to make it impossible to preserve it in a good condition; besides that a Flank disposed after that manner, can never defend the Passage of the Moat, nor flank the Breach, nor in the last place, uncover the covert Ways. As for *Monsieur le Chevalier de Ville*, who makes the Flank perpendicular to the Curtain, he has more Reason for what he does, than *Erhard*; though his Flanks are less than those which *Monsieur Vauban* makes use of, and that they do not batter the Moat sufficiently, nor the Counterscarps, which is the most essential part of the Defence. Besides, it is but too well found by Experience, that when the Counterscarp is gained, the Fort holds out but a short time; the Reason of which, if it be demanded, is because the disposing of the Places is so disadvantageous, that one Day sees them reduced to Dust; and the *Embrasures* made upon these Parapets, perpendicular to the Curtain, are too acute; especially if it be required that they should clear the covert Ways. I know it may be said, that it is easie to make an *Orillon*, or Ear, and a retired Flank in a circular fashion: But the *Orillon* will be too feeble, unless you allow it the half of the Flank, and the Curtain will not suffice for its Defence, not having room enough for several Pieces to be placed upon it; besides that,

there must be a mixture of great and small Shot, which will cause an inevitable Trouble.

Monsieur *Pagan*, a Person experienced to perfection in the Art of War, and one who has justly acquired the Reputation of being one of the most skilful Engineers of our Time, was the first that alter'd the disposing of Flanks perpendicular to the Curtain, by allowing them much more Overture; for he makes them perpendicularly upon the Line of Defence; and he gives very good Reasons for it in his Book of Fortifications; where he says, That his being present at above twenty Sieges, convinc'd him, that Flanks perpendicular to the Curtains, were of little durance. And he wonders that the Reputation given to the *Hollanders*, for their Perfection in the Art of Fortification, should be so great, since the Places fortified according to their Method, make so little Resistance; and for that there is not one which is well defended from the Canon: Nevertheless, we may presume to say, that Monsieur *Pagan*'s Method is not altogether without defects; for the Enemy may batter a Flank so dispos'd, before he come upon the covert Way: Therefore to make the best of all the Advantages which both the one and the other produces in his defence, Monsieur *Vauban* allows an Overture to this Angle, from 98 deg. to 106, as may be seen, Book IV. Ch. 1. Sect. 3. For by this means the Embrasures made in the Parapet in this Flank, perfectly uncover the Moat, and the covert Way. And though Monsieur *Vauban* should not have made this Flank in a crooked Line, by means of the Orillon, and the retired Flank, however it ought to be preferr'd before others; because the Ravelin covers the Overture which is allowed it above the Perpendiculars to the Curtain, and consequently it is not too much exposed, besides that it considerably enlarges and diminishes the Faces, which are the weakest Parts of a Fortification.

CHAP.

CHAP. II.

Of the Flank.

HERE we must repeat what we have already said, That though the largest Flanks are the best; nevertheless it is a Thing disputed among the Engineers. *Marsheuser* made the Flank to a Square of 16 Fathoms; to a V, of 18; to a VI, of 20; to a VII, of 22; to an VII, as far as a *Dodecagon* of 24. *Freitag* made it to a Square of 12; to a V, of 14; to a VI, of 16; to a VII, of 18; to an VIII, of 20; to IX, of 22; to X, of 24; which Length he retains also in *Polygons* of 11 and 12 Bastions. *Goldman* made it a Square of 12; to V, of 16; to VI, of 18; to a VII, of 20; to an VIII, of 22; to a IX, till he came to *Polygons* of 12 Bastions of 24 Fathoms. In general, the *Hollanders* make their Flanks to a Square of 16 Fathoms, 2 Feet; to a V, of 18 Fathom, 1 Feet; to a VI, of 19 Fathom 1 Feet; to VII, 19 Fathoms 5 Feet; to an VIII, 21 Fathoms 1 Feet; to a IX, of 21 Fathoms 1 Foot and a half; to a X, 23 Fathoms, 1 Foot; to XI, of 24 Fathoms, 1 Feet. *Monsieur* the Couns of *Pagan*, allows the Flank in a Square, 19 Fathoms, 1 Foot; to a V, 24, *&c.* as you may see, *L.* 3. *C.* 16, & 17.

CHAP. III.

Of the Faces.

AS the Face is the most dangerous Part of a Fortress; and for that it is extreamly expos'd to the view of the Enemy, 'tis requisite that it should be as short as may be; for that, by how much it is the more advanced towards the Field, by so much it is the more liable to be attack'd: Whence it comes to pass that the Enemy of late generally makes

choice of that Part, to begin his Breaches. As to the length of the *Faces*, the Engineers differ as much one among another, as they do about the *Flanks*. *Adrian Metius* would have the Face to carry two third parts of the Curtain. Monsieur, the Count of *Pagan*, allows it in a Square 55 Fathoms, and permits the same Length for the *Polygons*. *Freitag* would have the Face to be always 48 fathoms, according to the practice of all the *Hollanders*. As for the Length of the *Faces*, after *Vauban*'s Method, see *Chap.* 16. of the Third Book.

CHAP. IV.

Of the Orillon, *and Flank retir'd; together with the* Brisure, *or Place where the Great Guns are to be planted.*

AS for what concerns the erecting of the *Orillon*, and Flank retir'd, according to Monsieur *de Vauban*'s Method, there needs no more than to read what he has written thereupon in the Second Chapter of his Third Book. But here is a new Method; which though it be not better, however it is as good.

1. After the Out-Lines of the Fortress are drawn, divide the Flank of one of the Bastions into three equal parts, and the Face of the opposite Bastion into two, as, A, B, B, C.

2. Draw from the Point B, which makes the middle of the Face, a Line through the third part of the Flank, which is the neareſt to the Angle of the Shoulder D, prolonged in the Body of the Bastion of 7 fathoms, as D E.

3. Divide this same Third part of the Flank, into two equal parts; as F G, and G D; from which Point G, erect a Perpendicular of about two fathoms, as G H. Lastly, Set the Compass upon the Point H, and so draw the Rounding of the *Orillon*, joyning F D, together.

4. Draw from the re entring Angle of the Moat P a streight Line through the Angle of the Curtain L, prolonged in the Body

Body of the Place, of an equal bigness to the Line D E; that is to say, of five Fathoms, as, K I; to the end that you may have the *Brisure*, where you may place the piece of Cannon that points towards the Half Moon, & cannot be batter'd from the Field; because it is, as it were, covered by the *Revelin*. Lastly, To make the Rounding of the Flank retir'd, take the Distance K E, between the Points of the Compass, and make Sections toward the Moat, in L; from whence afterwards draw the Arch from K to F.

It cannot be said, but that these *Orillons* are very good; for these Roundings give less advantage to the Enemies Cannon, and enlarge the room, as well for placing the Cannon, as for the Musketeers. If you object, That the Distance from that part where the Enemy may pass the Moat, is too great. I answer, That the principal Defence of the Small Shot to hinder the Passage of the Moat, consists in the *Tenaille*; where you may set a Body of Musketeers, to fire continually.

Upon this Method, Monsieur *de Clermont* observes, That the *Orillon* of the Square would be too little, if you allow it no more than the Third Part of the Flank, as to the *Polygons*; and therefore he requires Two Fifth Parts of the same Flank, for the *Orillon*. See the Plate P. *Fig.* XXII. at the end of the Third Book.

CHAP. V.

Of the Curtain.

IN regard that the Curtain ought to cover the greatest part of a Work, it is requisite that it should be of a reasonable Length; that is to say, that it should never be shorter than Sixty Fathoms, and never longer than an Hundred. *Marchese* allows it 72 Fathoms, and *Freitag* as much, *Goldman* would have the Length to be of 96 Fathoms; *Anthony de Ville* 100. *Tieu* makes it 74 Fathoms in Length; *Himsel* 84. Monsieur *de Clermont* allows it Three Fifth Parts of a *Poly-*

gon. The Count *de Pagan* 60 Fathoms. *Monsieur de Vauban* forms it according to the Plurality of the Bastions. As you may see *Lib.* 3. *c.* 17.

As to the Figure of the Curtains, there are some Engineers, who will have them to be, as is mark'd at the Letter A; of which the Construction is such. See the Plate P. *Fig.* XXII. at the end of the third Book.

1. Divide the Line A B into 5 equal parts, as A D, D M, N C, and C B, and take 1 for the *Demi-Gorge*, as B C, A D.

2. Divide the same Line A B into three equal parts, and take one for the Capital, as B E, A F.

3. Where these three Parts are marked, as at R and G, bring down from the Points R, G, two Perpendiculars, of which let each have the third part of the Capital Line for its length, as R H and G I, and then joyn H and I together by a Right Line.

4. Make upon the Points D and C, the Angle of the Curtain of 100 degrees, and allow to the Flank the length of the *Demi-Gorge*, as D P and C Q. This being done, joyn E Q and D P together, to have the Faces. The defect of the Curtain are, 1. That it is too short. 2. That the Fortification takes up too much room. 3. That it renders the Bastion too Acute.

Others there are that form an Angle without side, as that which is marked with the Letter B. The Construction of which is after this manner.

1. Divide the Line A B into five equal parts, as A C, C D, D E, E F, and F B.

2. Divide the first Line A B into three equal parts, and allow one for the Capital, as A I, and B K; then joyn H I and B K together, to gain the Faces.

3. Divide the Curtain C F into two equal parts, and upon the middle, marked with the Letter L, erect a Perpendicular, which has the half of the Face G K, as L M.

4. Draw from C F two streight Lines to the Point M, and your Curtain will be made. See the Plate P. *Fig.* XXIV.

Others make the Curtain of a Circular Figure within side, like

like that which is marked C: The Construction of which is as follows. See the same Place. *Fig.* XXV.

Having observed what has been said touching the three first Points of the Preceding Curtain, take the Extremities of the Curtain B C, and make two Arches to cross or cut one another underneath; and from this Point of the Intersection draw an Arch, from one end of the Curtain to the other.

Lastly, There are others that form the Curtain of a Circular Figure without-side, like that which is mark'd D. The Construction of which is like to that which we have already describ'd, only that here you make the Intersection above the Curtain in E: From which Point you afterwards draw the Arch from one end of the Curtain to the other.

The Breast Curtains are those which are drawn streight or right from one Flank to another. See the same Plank P, at the end of the third Book. *Fig.* XXVI.

CHAP. VI.

Of the Parapet.

IN regard that this Work is raised to cover the Cannon and the Soldiers which defend the Place, it must be allowed a reasonable heighth and breadth. *Villarius* allows it six Feet in heigth, with a Foot of sloping within side; to the end the Soldiers may be able to stand the better when the Parapet is covered after that manner. The heighth without side from the *Cordon* ought not to be above four Feet, because the sloping which is made by those different Heights, inward and outward, gives the Soldier an easier view of the Counter-ways, and the Moats that are before him. As for the Thickness of the Parapet, Monsieur *Clermont* allows it for the Basis, the third part of the Basis of the Rampart. The Count *de Pagan* makes it three Fathoms broad. Of which opinion are several others, as *Goldman*, *Freittag*, and Monsieur *Vauban* himself. So that we may boldly say, That

the Thickness of the Parapet is good, when it is not less than 18 Feet, nor broader than 24. For being weaker, the Parapet cannot long resist the force of the great Shot, which would soon level it with the Earth; and being thicker, it would hinder the Soldiers from the sight of the Moat and the Covert way.

If you would line the Parapet, it must be allowed a little sloaping, that the Soldiers may have the better footing. The best Lining of Parapets is with Turf. As for the Earth or Mould which you are to make use of in erecting a Parapet, it is very requisite to mix it with Withy Twigs, or Brambles, and to sow it with any Weeds that take a deep root, to bind the Earth together, so that the Cannon may not easily crumble it down. Hay of *Burgundy* is also very good for this purpose, in regard that there is no Plant that puts forth more or deeper Roots.

CHAP. VII.

Of the Banquets.

AT the foot of the Parapet, upon the Plat-form, are usually made two little Steps or small Banks, of which the first is about two Feet broad. *Goldman* makes it four Feet, *Freitag* 3. the Count of *Pagan* 2. Monsieur *Clerac* the same; and one Foot, and one Foot and a half high; wherein they all agree. There are two made, for that the Soldiers are not all of an equal heighth. So that the low Men are placed upon the upper Step or Bank next the Parapet, and the taller upon the lowermost: so that every one may have a view from the Parapet, and discharge at his ease.

CHAP.

CHAP. VIII.

Of the Rampart.

THIS Work is the Principal Piece of a Fortification; and therefore the Rampart ought to be higher and broader than any of the rest of the Parts. *Fournier* allows for the Breadth of the Rampart from 15 to 25 Paces; and for the Heighth, from the Level of the Field from 15 to 25 Feet. *Freitag* takes for the Base of a Square 9 Fathoms: of a Pentagon, 10. of a Hexagon, 11. of a Heptagon, 12. of an Octagon, 13. of an Enneagon, 14. and observes this Breadth in all other Polygons. The Heighth of the Rampart he thinks sufficient if it be but 3 Fathoms; and he raises the said Rampart above the level of the Feild three Fathoms. *Monsieur Clermont* would have the fourth part of the Face allowed for the Base of the Rampart, or in the Feild from 8 to 12 Fathoms; believing that a larger breadth would not only be useless, but also prejudicial, by reason of the great Space of Ground it would take up, and the vast quantity of Earth it would require. *Monsieur de Vauban* never makes the Base larger than 11 Fathoms, alledging the same reason that *Monsieur Clermont* brings. The heighth of his Rampart never exceeds four Fathoms, whether to cover the Houses of the Place, or to command the Enemies approaches: For being lower, the Garison within could never command the Enemies Works. If they tell me that in some places a higher Rampart is requisite; I answer, That a good *Cavalier* supplys that defect, without raising the whole Rampart any higher. The upper Breadth of the Rampart ought to be from 4, to 6 Fathoms; for being too narrow, it would require that the Parapet should be made too broad to consume the rest of the Earth, appointed for the Rampart; besides that it would be prejudicial, because too broad a Parapet hinders the Soldiers from the sight of the Moat; and being too large, the remainder of the Earth would not suffice to make

a good

a good Parapet, which is also very dangerous. As for the sloaping of the Rampart, it has been said above, That there ought to be allowed to the *Talus* or sloaping of the Rampart, as the Earth tumbling down from the top to the bottom takes up of it self. For every Body knows, that, according to the badness of the Earth, the sloaping ought to be more or less, the better to sustain the Rampart. The best Earth is that which is called Grey Clay, next to that the slimy Earth, because that by reason of their clamminess, they better resist the inconveniencies of Heat and Rain; besides they bind reddily well together, support themselves with little sloaping, and feed the Roots of Weeds and Grass better. To every foot of Earth, where the Rampart is raised, two Branches of Willow are to be set no bigger than a Man's Thumb: Besides that, the Earth is to be so hard rammed down, that it may sink four or five Inches, and that there remain not above seven or eight. Lastly, You ought to sow with Hay-Seed and Weeds upon the outside in every Row, to the end the Earth may intermix with the Roots. Nor is there any Herb that casts forth more or deeper Roots than the Spanish Trefoyle, or winged Clover. Moreover, you ought to level the Platform so, that the Plane of it may decline somewhat towards the City, to carry off the Water. When you plant Trees upon the Rampart, it is a great Ornament in time of Peace, and a good Provision in time of War. There are some Engineers that do not like this Advice: for they say that the Wind makes such a noise, when the Branches hit one against another, that the Men can hardly hear one another: besides that, it is a great hindrance to the Cannon, which is a consideration not altogether to be rejected. Lastly, We cannot pass by in silence the Fancy of some Men, who proportion the thickness of the Rampart to the number of the Bastions of the Fortification; as if a *Hexagon* ought not to have as good a Rampart as a *Decagon*. I would fain ask them, whether small places are not attacked with the same Arms as great ones? If they answer, That there is more Earth taken out of the Moat of a large Place than a small one; we reply, That it may be spent upon the *Glacis*: for that the larger the *Glacises* are, the better they are.

CHAP.

CHAP. IX.

Of the Embrasures and Merlons.

MANY have proposed several sorts of *Embrasures*, but the best are those which are streight and narrow within side, and wide towards the Field; to the end that the great Guns may play with more ease toward the right and left. The *Merlons*, to the end that they may be good, ought to be made of Earth, the most easie to be tempered that may be: And this Earth ought also to be mixed with Withy Twigs, or Brambles, provided they take Root, after which they are to be lined with good Turff.

CHAP. X.

Of the Moat in the Body of the Place.

IN regard that every Fortress ought to be environed with a Moat, we shall briefly examine which sort of Moats are first to be preferred. Some make them broad, others narrow, one draws the Moat parallel to the Faces, another draws them narrower toward the Point of the Bastion, than in any other Places. Lastly, one is for a dry Ditch, another for a Moat that is full of Water. One prefers a Moat very deep, but not so broad; another would have it broad, but not so deep. Let us examine every one of these in order. The Count of *Pagan* makes his Moat for a *Tetragon* 16 Fathoms broad; and for *Polygons* of 10, his depth does not exceed 3 Fathoms. Monsieur *Clermont* takes from 16 to 20 Fathoms, for the Breadth of the Moat, without any regard to the Plurality of Bastions; and makes it hollow from 18 to 20 Feet. *Errard* would have it broad from 15 to 25 Paces, and deep from 15 to 25 Feet. *Gelarius* makes his Moat 3 Fathoms deep, and

and broad at the top about 19, and at the bottom near 13. Monsieur *de Vauban* prefers Monsieur *Clermont's* Way before all the rest, as to the Breadth and Depth of the Moat; For as to the way of drawing out the Moat, Monsieur *Clermont* makes it narrower toward the Point of the Bastion than toward the other Parts; more especially if the Flanks are large; for he says that otherwise, it would be requisite that the Moat should be as large as the Length of the Flank, or else much more narrow; and in the first case there would be a necessity of making it very shallow, which would render it defective, for that the Enemy would easily shoulder himself into it. And supposing it were of a reasonable Depth, there would be Ground which no body would know what to do with, by reason of the extraordinary Wideness. And in the second case, there would be one side of the Flank, that would not uncover the Moat, which would be against the Rules of Fortification. Others answer first, that if the Moat were as large as the Flank, with a moderate Depth, that Wideness would hinder the Enemy from crossing the Moat without great loss of his Men. But if the depth were a little more than ordinary; and it should be asked, what should be done with the Earth taken out of the Moat; they reply, 'twould make the *Glacis*. The learned may judge as they please; but for my part, I hold with them, that are for making the Moat parallel to the Line of Defence. If they still object, that the rounding of the Moat being as large as in other Places, all the whole Curtain and Face of the opposite Bastion cannot be discovered; we must answer, that if they would uncover those Parts above the rounding, they ought to make no Moat at all, because the Point of the Bastion it self is not proper for that. Add to this, that if the Moat be made narrower toward the Point of the Bastion, the Enemy having once gain'd the Point, the Earth of which is fill'd one part of the Moat, he will easily pass it by, throwing Bayins over the Ruins of the Bastions, which will shew him, as I may so say, the way to enter directly into the Bastion.

The next Question is, whether a Moat full of Water is to be preferred before a dry Moat; which a distinction between the great and small Places will quickly decide. As for great

Fortresses

Fortresses, it cannot be deny'd but that dry Moats are to be preferred before those full of Water. Some will object, that a Moat full of Water secures a Place against Scaladoes and Surprizes; besides that, is very hard to be filled up; and that it affords great Trouble to the Enemy, that would either pass it, or cover himself, or fight within it: And that on the other side, besides that a dry Ditch is extremely exposed to Surprizes, very easie to be filled up, and no less easie to be passed; it is very proper to cover the Enemy in making of Mines, by means of which he may blow up a great Part of the Place. But I answer to this, that as well a Moat full of Water hinders the Sallies of those within, without the help of Boats, which make so great a noise, that 'tis impossible but the Out-Sentinels near the Place besieged, must hear it; and the same that is to be said of the Sallies, is to be said of the Retreats. Beside, if the Water that fills the Moat be not a running Stream, it begets an unwholsome Air, causes frequent Distempers, and renders the Soldiers less courageous, by reason of the noisome Stenches that arise out of it; and on the other side, besides that, a dry Moat is more commodious for Sallies, and safe Retreats; there is no Fear of Sickness proceeding from noisome Water, and unwholsome Air. To say something of the Convenience of Mines, which the Enemy has to make, you must make a *Cuvette*, or little Dike in the middle of the Moat from 15 to 20 Foot broad, and very deep; for the deeper it is, the better it is: Surround it with a good Parapet with Palisadoes round about; and so you will be secure from Mines and Surprizes. As for little Fortresses, a Moat full of Water is better than a dry, because Sallies, Retreats, and Succors, are not so necessary as in great Places. The Moat is also to be rounded before the Point of the Bastion, to the end that it may be of the same Wideness quite through, and that it may not advance too far into the Field; which it would do if it were pointed. You may also set a Corps du Guard upon this Rounding, the better to defend the Covert way. Lastly, When you would line the Moat, they never allow it any great *Talus* or Sloaping; only they allow it such as the Earth of the Rampart, and the Moat gives of it self.

CHAP.

CHAP. XI.

Of the Moat belonging to the Outer Works, and the Avant-Moat.

THe Moats belonging to Outer-Works ought to be neither so great, nor so deep, as that which belongs to the Body of the Place: For a Wideness of 12 Fathoms suffices for these Moats, being hollow from 12 to 15 Feet.

In short, there are some Engineers, who make a little Moat about the *Glacis*, though others practice quite contrary. The first pretend that the Earth taken out of the Moat, serves to fortifie the *Glacis*, and secure the Covert-way. On the other side it is said, that the Avant-Moat serves only to hinder the Sallies and Retreats of the Garrison: and this Reason prevails; for if you have need of Earth, the better to secure your cover'd Way, you may make the Moat of the Body of the Place deep, and employ the Earth which you take from thence, for that purpose. If you think that this Moat prevents Surprizes, and the Approaches of the Enemy; I answer, that a good wide *Glacis* will do the same, without being at so much Charge for an Avant-Moat. Nevertheless sometimes they are constrained to environ the *Glacis* with such a Moat: They make it five Fathoms wide, and two deep. Such a Moat as this you may see about the Citadel of *Strasburgh*.

CHAP. XII.

Of the covered Way, and of the Glacis.

A Good Covert way will require at least five Fathoms in Breadth, especially if the Ground will permit it; but one broader is useless and prejudicial, unless its Parapet be higher than ordinary; otherwise it is easily pierced by the Enemies

Enemies Batteries: And one less wide, is defective in this, that there is not room for the great Guns and Men, but one will hinder the other. Besides, that when it is too narrow, it is not flanked on so many Parts as it ought, and it may be said, that this part must be then too much in view of the Enemy, whose chief Effort in a Siege it is, to make himself Master of the Covert-way.

This Covert-way has no other Security than the *Glacis*, which serves it for a Parapet round about. The Wideness of it ought to be at least from 25 to 40 Fathoms, losing it self insensibly in its Inclination towards the Field. But the more to secure the Covert way, we must say that the largest *Glacis* are the best; for that by this means, the Enemy lies more open; and the less it has of Sloapings, the better they are, because the small Shot is the more secure in the Covert way, and does more Execution. In short, there is nothing to be suffered about the *Glacis*, that may favour the Enemy in his Approaches; So that if the *Glacis* be higher than five Foot above the Covert way, you must put one or two Steps below, as need shall require for the short Stairs'd Sallies.

CHAP. XIII.

Of False Brayes.

HEre it is, that some will ask me why the *French* admit no *False Brayes* in their Fortifications, as being a second Defence, and an admirable Work to dispute the Counterscarp with the Enemy, and to hinder him from crossing the Moat. However it is certain, that small Shot does more Execution from a low than a high Place. Besides, that the small Shot placed in the False Bray, doubles the Defence of it, as that of it doubles the Defence of the Place. But if you talk of the Defence; Why do you then put the Counterscarp before the Faces, knowing that those Parts defend nothing? You will answer, that this is to dispute the Passage of the Moat.

But

But consider, that the Enemy having broken the Parapet of the Point, may afterwards pierce with his great Guns the Walk that runs all along the Face: Besides that, the ruines of that Work is very advantageous to the Enemy, who would willingly have wherewithal to fill the Moat. As for the part of the Falſe *Bray* that is before the Curtain, it is no longer good, becauſe it does not flank the Faces of the Baſtions, nor hinder the Paſſage of the Moat, which is objected always for the principal Reaſon. Nevertheleſs the remainder of that Work, which is before the Flank, will be good: But know that this part is eaſily rendered unſerviceable, by the Ruine of the Rampart, and the Parapet of the Flank, which falling within-ſide, fills up its Platform: And if the Rampart be lin'd, the Splinters of it maim the Soldiers, that guard that Flank of the Falſe *Braye*. To remedy which Defect, the French now adays erect *Tenailles* in the Moat before the Curtain, and before the Flanks ſeparated from the Body of the Place, by a little Moat, to the end the fall of the Rampart of the Body of the Place may not kill or wound thoſe that are in it, being lined with Walls. There is nothing of all that you talk of Falſe Brays, that can be attributed to theſe Tenailles; beſides that they caſt not the half of what thoſe other Works do.

CHAP. XIV.

Of Cavaleers.

CAvaleers are one of the beſt Defences of a Place, becauſe they moſt notably ſcowre the Field, which obliges the Enemy to open his Trenches at a great diſtance, in regard theſe are as ſo many ſecond Baſtions, which are oppoſed to the Enemy. And moreover that they defend the Paſſage of the Moat, command the Covert-way, and above the *Glacis*, 'tis certain, that being well diſpoſed, they may defend the Head of the Breach, which the Enemy ſhall make in the Face of the Baſtion, wherein thoſe *Cavaleers* are erected. Now in

in regard that Opinions are different, as well in respect of the place where they are to be set, as in regard of their Figure. Let us see the *Reasons* both of the one and the other.

I.

There are some that would have the Cavaleers plac'd upon that part of the Curtain, which discovers the Face of the opposite Bastion; that is to say, upon the Lines of the second flank, as A; the Construction of which is such. See the Plate Q, Figure XXVII.

1. Bring down a streight Line perpendicularly under the flank, and upon this Line put two third parts of the *Demi-gorge*; as A, B.

2. Divide the Line A B into two equal parts; as, A C.

3. And prolong perpendicularly the Point C, till this Prolongation be equal to the *Demi-gorge*; as, C, D.

4. Bring down also a Perpendicular from the Point D, of the Length C B; as, D E; and at length join B E, together by a streight Line.

Having rais'd the Cavaleer to a just Height, they give it a Parapet of three Fathoms, and two Banquets, as is shewed.

But it may be objected against this Situation, that the Cavaleer does not flank, but very obliquely; and by consequence, that the Effects of it are of little consequence.

That the Ruines which the Enemy's Cannon will make, being oppos'd to it in Front, filling between the Curtain, and the Cavaleer, will hinder the Execution of the Small Shot of the Second Flank.

II.

Others lodge the Cavaleer in the middle of the Curtain, and give it a Triangular Figure; alledging, That in that case one and the same Cavaleer may flank two Faces of the Bastions. To which it is answered, That a Cavaleer cannot be erected after that manner, but in Places which have more than half the Curtain for the second Flank; which would be very difficult, unless it were in Cities where the Angles of the Bastion are of a very large Overture. For to say, we ought to make these second Flanks very large, as well to augment the Line from the Curtain, as to gain room for placing of the Cavaleer,

valeer, this is to make Bastions in a Place, that serve for nothing; because, that by this means, the Flanks are made so small, that they seem to be only for Ornament.

2. That the Enemy stands in no fear of the Firing from a Cavaleer dispos'd after that manner, when once he is lodg'd upon the Counterscarps, because it is too high, and the Cannon cannot plunge low enough.

The Construction of this Cavaleer is such. See the Plate Q. *Fig.* XXVII, B.

1. From the Curtain bring down a perpendicular Line, and put there above 14 Fathoms; as, A B.

2. Take that Distance, and draw from the Point B a Circle.

3. Divide this Circle into Three equal parts, beginning from the Point A; as, A C, A D, and C D; which join together by right Lines; and this shall be the Base of the Cavaleer.

4. Draw on the Sides A C, and A D, the Base of the Parapet of 3 Fathoms. But it is to be observ'd, That these Cavaleers are not to be erected but from 9, to 10 Feet above the Platform of the Rampart, unless there be very strong Reasons to raise it higher. In the mean time, 'tis very true, that this Cavaleer is not better than the preceding, because the Angles of it are very acute; for when the Angle A is carried away, all the rest is worth nothing; since neither Cannon nor Soldiers can subsist upon the side A C, and A D, by reason of the Enemy's continual playing upon them.

III.

Some raise the Cavaleers upon the Platform of the Bastion, and dispose it in such a manner, that the Faces and Flanks of the Cavaleer are parallel to the Faces and Flanks of the Bastion; as C. The Advantages that proceed from this Disposition, are, that the Enemy being got upon the opposite Counterscarps, will be troubled to lodge his Cannon there, by reason of the Cannon upon the Flank, and upon the Cavaleer; which playing without ceasing, will dismount the Enemy's Artillery; hinders him from raising Shouldering; to secure himself: Besides that, the Breach of the opposite Face is much better defended, and the Field better scowred.

But

But one would think they might enjoy all these Advantages without possessing the Plat-form of the Bastion; and by that means deprive themselves of the Advantage of making Entrenchments; which favour the Defence of Assaults. Besides that, these Cavaleers are of no use for the Defence of the Breach made in the Bastions where they stand. And there is this more over, That the Besieger may at the same time, with a Mine carry away a part of this Cavaleer with the Face of the Bastion. And lastly, 'Tis for the Defenders to deprive themselves of several Advantages, which we shall observe in the following Method, and which has all the Advantages of the preceding Situations, without being obnoxious to their Imperfections. But before we speak of this Cavaleer, observe the Construction of it; of which we have set down the Advantages, and Disadvantages.

1. If the Bastion is empty, it ought to be fill'd up, till it come to be as high as the Plat-form.

2. Which being done, raise that which was empty upon the Plat-form, from 9, to 10 Feet.

3. Having levell'd that Height toward the Top, you shall draw the Base of the Parapet of three Fathoms, which ought not to be rais'd above 6 Feet; because the Cannon are not to be placed higher; for that being higher, they would require a Battery to be raised on purpose.

IV.

Lastly, There are others that place the Cavaleer within the Bastion, of a circular Figure, disposing it thus;

1. They pro'ong a Line of Defence in the Body of the Place, till it cut the Radius of the Centre at the Point A.

2. They divide the Distance between this Point A, and that of the Gorge B, into two equal parts; as, AC, CB.

3. From the Point C, they draw a Circle, which makes the Base of the Cavaleer.

4. They raise this Place from 9, to 10 Feet, above the Plat-form of the Bastion.

5. They allow this Cavaleer a Parapet Three Fathoms wide, and One high.

6. The best Lining of this Cavalier is with Turfs; for if it were of Mason's Work, the Bricks and Stones, which will be shattered from it, would annoy those that defend the Rampart.

It is objected against this, That they do not leave room enough between the Foot of the Cavalier, and the Parapet of the Flank, for the free passage of the Men that are to defend the Breach, and to traverse the Guns, which are upon the Flanks of the Bastion, because their Carriages being long, do they will take up a great deal of Ground.

But it is answered, That this Cavalier being distant at least 9 Fathoms from the Parapet, this Passage seems to be more than sufficient to communicate between the Rampart and the Bastion, in respect of the place of the Cannon; and in regard the largeness of the Base of the Cavalier, may be lessened, if it be found to incommode the Passage. We must confess, there is room enough, not only when the Cannon are mounted upon small Carriages, but that when they are mounted upon their usual Carriages, these Cavaliers bear them above all others.

CHAP. XV.

Of Counterscarps.

IT may be said, That Counterscarps cut in the Rock, are the best; for, besides the difficulty of opening them, to descend into the Moat, they need no *Talus*, or Sloaping, as being sufficient to support themselves.

Those that are lined, are to be preferr'd before those that are not, by reason of their durance; though it may be fear'd, That the Enemy will make use of that Lining, to secure himself, and make a Gallery all along with Embrasures, to play upon those that defend the Moat. But this Reason signifies little; for when a Moat is full of Water, the Counterscarp ought to be lin'd of necessity; otherwise the Earth being

moistned

moistned by the Water, tumbles easily down; but if the Mine be dry, a Lining is not so absolutely necessary. The Sloping ought to be allowed after such a manner, That if the Enemy should enter with the Soldiers of the Garrison upon some hot occasion, he could not easily get out again. That part of the Counterscarp which is before the Point of the Bastion, ought to be rounded, to gain the Space above the Covert-Way, provided you can keep there a Body of your Men, to be on a condition to sustain an Assault.

CHAP. XVI.

Of the Streets, Places of Arms, Corps de Guard, and Magazines.

HAving shewed, Book 3. Chap. XX. how to make the Streets into Fortresses, we shall first speak of the Places of Arms. The Grand Place of Arms ought to be in the middle of the Fort; the construction of which is contained in Chap. XX. Book 3. And the other Places of Arms ought to be on the side of the Bastions, the biggest of which ought to be proportioned so, as to hold 200 men for every Bastion; or 300, if they are to sustain a Siege. And in regard that every Man marching in Battalia, takes up no more than Three Feet in Rank, and Seven in File, it is easie to know how many Men will serve for every Fortress, and how large the Places of Arms ought to be.

The most numerous *Corps de Guard* ought to be in those Parts, where the most numerous Guard mounts. There must be one on two Chimneys at least; and a little Theatre of Wood all along, about three Foot high from the ground, and seven or eight Foot broad, for the Soldiers to lie upon. The other *Corps de Guard*, built after the same manner are to be placed near the Gates, or Passages.

In regard that there is always Occasion for Ammunition, that is, for Powder and Ball, for the Soldiers that are upon the Ramparts, there must be Arsenals near at hand. But great care must be taken to put the Powder where it may not take Wet; much more, where it may be in danger of being Fired.

The Magazines of Hay and Provender for the Cavalry, ought to be near the Stables where the Horses stand. The others must be built in the most secure Parts of the Garrison.

In regard the Soldiers, as well Foot, as Horse, are often lodg'd in Huts; these Huts are to be set up near the Rampart, to the end, that in case of necessity, they may be ready upon the Rampart, to defend the Place. To which purpose, the Town is to furnish them with Beds, Tables, Benches, & Hangings for the Officers Chambers, under whose Government the Soldiers are to serve; their Presence being necessary, to keep them in order, and from being injurious to the People of the Town. Every Hut ought to be so large as to hold four Soldiers. Every Captain ought to have a particular Chamber, and another for two Lieutenants. These Huts ought to be 18 Fathoms long, and 7 and a half broad; and four Fathoms high; though there are some that are higher.

CHAP. XVII.

Of the Gates.

A Gate, if it be well placed, ought to be in the middle of the Curtain; because that in that part it is defended with two Flanks, which lie on both the extremities of it. The Gate cannot be too well secured, because that there Surprises are generally most attempted, whether by Petarding or by Intelligence from the Garrison. Some place the Gate in the Flanks, because, say they, the Sallies are by that means more private, and for that those Gates look athwart the

the opposite Flank. But, besides that, being so placed, they very much weaken the Flanks, which are almost the chief strength of the Place, and hinder by that means the opposite Face to that Flank from being well defended; they also hinder the use of the retir'd Flanks and the Tenailles.

As for those that are placed in the Faces of the Bastions, they are worse dispos'd; not only because it is a kind of a Breach already made, but because they are not Flank'd, but by a part at a great distance: The Sallies also are too much in view; nor can they be secur'd by any Work, but such a one as is not Flank'd; which is a very great defect.

The Wideness of the Gates ought to be from 14 to 16 Feet. The Height from 15 to 17. The Thickness like to that of the Rampart of the Wall. They ought to be all vaulted, or else the greatest part of them, and well guarded.

There must be great Stones laid at the Extremities of the Gates to hinder the Carts from spoiling the Wall. The Wood of the Gate ought to be of good Oak, join'd and fasten'd with good Nails and strong Bars of Iron.

CHAP. XVIII.

Of Back-Doors, or Sally-Ports, and Draw-Bridges.

TO sally out of the False Brays, Sally-Ports are made of such a wideness that the Cannon may pass through them: that is to say, they ought to be from 7 to 8 Feet wide; and from 8 to 9 Feet high.

The Draw-Bridges are made after several Fashions; but the most usual are made with Flyers. Their Length and their Wideness ought to be proportionable to the Borders or Frame of the Gate which are to hold them, being drawn up. The Arms ought to be from 8 to 9 Inches thick, as also the Beam that joins them.

The shoulder to which the Arms are annexed, and upon which they are to turn, ought to be from 14 to 16 Inches in Diameter. The Extremities being bound about with two good Circles of Iron; you must drive through the Center two Iron Pins, a Foot long, and two or three Inches in Diameter, to the end that it may the more easily move upon a strong Band of crooked Iron, which is to be joined to the Threshold and Jumbs, or Side-Posts, of the Gate. The Pyers are to be twice the height of the Gate, at least, and one Foot in Diameter. The Inner Square must be travers'd with a St. *Andrew's Cross*, which will serve for a Counter poise. The Chains are to be of Brass, to the end that the Bridge may never be let down without making a noise.

CHAP. XIX.

Of Bridges.

THE Bridges of a Town are to be from 14 to 15 Feet wide; lower than the Field, and somewhat round. When they are streight and even, they ought to be made a little higher in the middle than toward the Extremities, that the foot of the Gate may not be discover'd. Though the Supporters of Bridges may be of Stone, nevertheless they will be better, if their Planks and Rayls are of Wood, that they may be the more easily cut down upon occasion. When there is no Half Moon before a Gate, it is certain that the Bridge which crosses the Moate ought to be the wider, because there must be a good *Corps de Guard* upon it, and a Draw Bridge. But if there be a Half-Moon, some turn aside the way all along the Gorge of the Half-Moon above the Counterscarp, and make a *Corps de Guard* and a Palisado, which hinders the entrance of the Enemy. Others cause the Way through the Extremities of the Pieces. And a good *Corps de Guard* ought to be set at the end of the Bridge with a Portcullice.

A NEW TREATISE OF Fortification.

BOOK V.

CHAP. I.

IN regard that Fortification is either Continual, or Transitory, we shall now speak of the latter, as having given full Instructions for the first; Let us begin with a Redoubt.

Of the Raising a Redoubt.

1. Make a Rectangle Square, each side of which contains from 12 to 20 Fathoms.

2. Within this Square draw the Base of the Rampart three Fathoms large; and that of the Parapet from 3 to 5 Feet. The Height of the Rampart above the Level of the Feild ought to be nine Feet, and that of the Parapet above the Plat-

Platform of the Rampart, of five, as is usual: or of seven, when there are two Steps or Banquets: though sometimes they raise the Rampart a little higher, as necessity requires.

3. About the Rampart toward the Field draw another Parallel three Feet wide, which is call'd the *Berme*.

4. About the *Berme* make a Moat of four fathoms, with a Rounding before the Points of the exteriour Sides: the Depth of the Moat ought to be about eight or ten Feet.

5. The Bridge for entrance into the Redoubt ought to be ten or twelve Feet broad, when you would bring the Cannon into it; otherwise five or six Feet of breadth will suffice. See the Plate Q. *Fig.* XXVIII. in *Chap.* 14. *Lib.* 4.

CHAP. II.

Of the Half Redoubt.

1. DRaw a Line of 17 Fathoms, as A B.

2. Make an Isosceles Triangle of 12 Fathoms from the Points A B, as A C, C B, and join A C and C B together.

3. Prolong the Line A B, and place upon the Prolongation on each side eight Fathoms and three Feet, as A D, B E.

4. All the rest is done, as in the precedent Work. See the Plate R, *Fig.* XXIX.

CHAP. III.

Of the Star-Square.

1. MAke a Square, each side containing 22 Fathoms in length, as A B, C D.

2. From the middle of each exterior side draw a Perpendicular

dicular of two Fathoms, as D E F G; and afterwards draw A B in the Point E, B C in the Point F, D C in the Point G, and D A in the Point H. The rest is done, as in the Redoubt. See Plate R, *Fig.* XXX.

CHAP. IV.

Of the Star-Pentagon.

1. DRaw a Circle of 17 Fathoms, and divide it into five equal parts, with 31 Fathoms 5 Feet, as A, B, C, D, E.

2. Join the Sides together, by ſtreight Lines, and divide each into two equal parts, let fall from the middle of them the Perpendiculars of 5 Fathoms, F, G, H, I, L.

3. Draw from the Points A, B, C, D, E, ſtreight Lines into the Points F, G, H, I, L.

4. The Baſe of the Rampart is 4 Fathoms. That of the Parapet 2. The Berme 3 Feet. And the Breadth of the Moat 5 Fathoms. See *Fig.* XXXI. of the Plate R.

CHAP. V.

Of the Star-Hexagon.

1. DRaw a Circle of 12 Fathoms, and divide it into 12 equal parts, as A B C D E F.

2. Join theſe Points together by ſtreight Lines, and divide each into two equal parts, then let fall from the middle a Perpendicular of two Fathoms, as G H, I K, M N.

3. Join theſe Points with the ſix firſt, as in the preceding Works.

4. Draw the Baſe of the Rampart of three Fathoms: that of the Parapet nine Feet, the Berme three Feet, and the Moat of five Fathoms. See the Plate R, *Fig.* XXXII.

CHAP. VI.

Of the Triangle of Half Baſtions.

MAke an equilateral Triangle, of which each ſide contains 24 Fathoms, as A B C.

2. Prolong the ſide A B, and place upon the Prolongation 8 Fathoms, as B E. Then alſo prolong the other ſide B C, and place upon the Prolongation 8 Fathoms C F. Laſtly, Place upon that of the Line C A the ſame diſtance, as A G.

3. For the *Demi-gorges* take the ſame diſtance, as B H, C I, and A L, and then raiſe Perpendiculars upon the Points H, I, L. And for the Flanks a length of four Fathoms H M, I N, and L O. This done, join the Points M, E, O, G, and N, F together, to gain the Faces: and thus you have the Deſign of your Triangle.

4. The Baſe of the Rampart takes up three Fathoms and a half. The Baſe of the Parapet 1 Fathom 4 Feet. The Berme 3 Feet. The Moat 5 Fathoms. It ought to be parallel to the Flanks, and round before the Points of the Half Baſtions. See the late R, *Fig.* XXIII.

CHAP. VII.

Of the Square of the Half Baſtions.

1. MAke a Square, each ſide containing 24 Fathoms, as

2. Prolong the Line, B A, and upon the Prolongation place 8 Fathoms, as A E. Then make that of the Line A D, of the ſame diſtance as D F. This done, prolong alſo the Line B C of 8 Fathoms as C G. Then make the Line C B of the ſame length as B H.

3. For

3. For the Demi-Gorges, take also 8 Fathoms, B, M, A, L, D, K, and C, L.

4. Raise upon the Points I, K, L, M, the Flanks perpendicularly, the length of which is 4 Fathoms, as I, O, K, P, L, Q, and M, N.

5. Draw the Faces, joining together N H Q G P F, and O E.

6. Having the Draught of the Square, let the rest be in the preceding Triangle. See the Plate S. Figure 14.

CHAP. VIII.

Of the Square of entire Bastions.

1. Make a Square, each side containing 32 Fathoms, as A, B, C, D.

2. From the middle of each side, let fall a Perpendicular of 4 Fathoms, as E, F, G, H.

3. Draw the Faces after *Vauban*'s manner, and add thereto 10 Fathoms.

4. Take the Extremities of the two Faces, and from one of them, let the Compass fall upon the Complement of the other; and in that part where it touches the Complement, join the same Point to the Extremity of the Face, which is the nearest to it, for the Flank. That done, draw the Curtain.

5. The Base of the Rampart contains 5 Fathoms, that of the Parapet 2 Fathoms 3 Feet, The Perimeter 3 Feet, and the Breadth of the Moat 6 Fathoms. See the Plate S. Fi-

CHAP.

CHAP. IX.

Of a Pentagon with entire Bastions.

1. DRAW a Circle of 27 Fathoms, and divide it into five equal parts, with one distance of 31 Fathoms, 5 Feet as A, B, C, D, E; and join the Points together by right Lines.

2. From the middle of each side let fall a Perpendicular of five Fathoms, and draw the Faces as usually, after *Vauban*'s manner; the length of which must be 10 Fathoms.

3. The Flank is made, by setting the two Points of the Compass upon the 2 Extremities of the Faces; of which the one falls upon the Complement of the Line of Defence, as has been said in the preceding Chapter: This done, join the two Flanks together for the Curtain.

4. The Base of the Rampart takes up 5 Fathoms.

The Base of the Parapet 2 Fathoms 3 Feet.

5. The Berme 3 Feet: The Breadth of the Moat 6 Fathoms. See the Plate S. Figure 36.

CHAP. X.

Of the Half-Hexagon with entire Bastions.

1. DRAW a Circle of 28 Fathoms, 4 Feet, and divide it with the same distance into 6 equal parts, of which you shall take three for your Temporary Work.

2. Divide into two equal parts each of the three sides; and from the middle let fall a Perpendicular of 5 Fathoms.

3. Draw the Faces as usually, of which let the length be 9 Fathoms.

4. The

4. The Flank and Curtain are made, as in the preceding Works.

5. The Baſe of the Rampart contains 6 Fathoms. The Baſe of the Parapet, 2 Fathoms 4 Feet. The Berme 3 Feet. The Breadth of the Moat 6 Fathoms. See the Plate S. Figure 37.

A Remark.

IN regard this Fortification is only for preſent uſe; and becauſe for that Reaſon it is ſometimes ſtronger than the other, the Draught and Proportion of it could not be aſcertain'd, as is a continual regular Fortification. Only we may ſay, that moſt frequently the Rampart of theſe ſorts of Forts is raiſed like thoſe of Redoubts. See the firſt Chapter, *Lib.* V.

CHAP. XI.

Of the Maxims of Irregular Fortification.

IRregular Fortification is that, of which all the Sides and Angles are not equal one to another. The Original of this Fortification proceeds from Ancient Towns and Cities; which were built after no regular Figure, and yet required to be encompaſſed with Walls and Baſtions, to defend themſelves againſt the Aſſaults of their Enemies. But becauſe it was impoſſible to fortifie thoſe irregular Places, and make them, in reſpect of their Duration, equal to regular Places, there are certain Maxims, according to which they may be inviron'd with a paſſable Fortification. For Example:

1. Every irregular Fortification ought to be made according to the Maxims of the regular as near as may be.

2. The moſt irregular Forts are the beſt, provided they be not too eaſie of Acceſs.

3. Entire.

3. Entire Bastions are to be preferred as much as may be before Half-Bastions.

4. No Face ought to exceed 60 Fathoms.

5. No Flank ought to be less than 16 Fathoms, if it be possible.

Therefore when you are to make an irregular Fortification, you must consider, 1. The Quality of the Situation. 2. The time allowed to make the Work. 3. The number of Men which are to be put in to defend it. 4. The number of Workmen. 5. The Victuals. After all you must draw the Plane, and fortifie it after the following manner.

CHAP. XII.

The manner of Fortifying an irregular Place, where there is nothing but the Field.

1. HAving the *Plane* of the irregular Place, divide each exterior side into two equal parts; and from the Middle let fall a Perpendicular

2. Upon each exterior side draw an Isosceles Triangle of 480 Fathoms.

3. Place upon these Triangles all the Parts and Distances which you make use of in a regular Fortification, and take the Distances across to put them upon the parts of your irregular Plane. For Example: if an irregular Pentagon be to be fortified, I take 480 Fathoms, and I make upon each exterior side an Isosceles Triangle A B C. Then I take 24 Fathoms, which I put upon the Triangle A B C, as C D E; of which the length D E, shall be the true Length for the Perpendicular of the Line A B: Which done, I put 60 Fathoms upon the same Triangle, as C F G the Length F G, shall be the just distance for the Face of my Work. After this, I put again 38 Fathoms 3 Feet upon the Triangle; and the distance taken across I find, will give me the true Length for my Complement of the Line of Defence. Lastly, I join the Flanks and the Curtains together, as in a regular.

regular. After which I divide the Flank into 3 equal parts; I draw the Brisure as usually, and retain one of the 3 parts of the divided Flank for the *Orillon*, and the two others for the hollow Tower. See the Plate T. *Fig.* 38.

CHAP. XIII.

Of the Body of the Place in an Irregular Fortification.

THE Body of the Place make thus;

1. Take 11 Fathoms for the Base of the Rampart, and put them upon each Triangle. The Length a-cross will always give you the true Breadth of the Base of the Rampart.

2. Take 3 Fathoms, and bring them round about the Place, without putting them upon the Triangles. Draw the Banquets as usually.

3. Take 20 Fathoms for the Breadth of the Moat, and put them upon all the Triangles, the Distance taken a-cross will be the true Breadth of the Moat for every side. The manner of making this Fortification is the same with that of the Regular. See the Plate T. *Fig.* 38.

CHAP. XIV.

To make a Half-Moon before these Fortifications.

BE sure to see whether the Length of the Curtain exceeds 100 fathoms or no. If it be from 100 to 140 Fathoms, take 50 Fathoms for the Capital of the Half-Moon or Ravelin. But if it be larger than 140 Fathoms, erect before the Ravelin another Work, whether a Horn or Crown-Work. If the Curtain be not longer than 100 Fathoms, take the half of the Curtain with the Brisure, for the Capital of the Ravelin, and the rest is done as in a regular For-

tification. For the Base of the Rampart is 8 Fathoms. That of the Parapet 3. The Breadth of the Moat 12. These Distances are to be put upon the Triangles, before the exterior sides of which you intend to place the Ravelin, and afterwards taken a-cross.

CHAP. XV.

To set other exterior Works before the same Fortifications.

IF an exterior Polygon exceeds 120 Fathoms, and that you have full room to erect a good exterior Work before it, whether Horn or Crown-Work; as you may see in *Fig.* 39. which is a Crown-Work made according to the Rules of *Chap.* 10. *lib.* 3. The parts of it ought all to be mark'd upon the Triangle.

A B, Is the Basis of the Rampart of the Ravelin, and the Horn-work.

C D, Is the Basis of the Rampart of the Body of the Place.

E F, Is the Breadth of the Moat belonging to the Ravelin and Horn-work.

G H, Is the Perpendicular of the Horn-work, from the end of which are drawn the Faces.

I K, Is the Breadth of the Moat belonging to the Body of the Place.

2 3, is the Perpendicular of the Body of the Place.

L M, Is the Face of the Horn-work.

N O, The Complement of the Line of Defence to the Body of the Place.

P Q, The Face of the Body of the Place.

R S, The Capital of the Horn-work.

T V, The Distance which joins the Point of the Capital to the Horn-work.

W X, Are the Wings of the Horn-work.

CHAP.

CHAP. XVI.

How to fortifie an Irregular Place already built.

TO avoid much Labour, you must fortifie the parts of an Old Fortification, and finish them, in the same manner as they were begun; unless they are gone utterly to decay; and then you may make what alterations you please. To the end therefore, that Money may be laid out to good purpose, when the Flanks are repaired, they must allow an Overture of 100 deg. If the Faces are tolerable, let them alone as they are, to avoid the vast expence in making others. Whence it comes to pass, that there is no ancient place which is fortifi'd after the *French* manner, because the Engineers have been always forc'd to labour upon *Dutch* Fortifications. As for the Rampart and Parapet, they may be better fortifi'd whatever Face they have. But to come to the Thing it self, let us observe the following Rules;

I.

The exterior Side, the Length of which is from 60 to 80 fathoms, requires a *Demi Gorge* from 14 to 15 fathoms, and a Flank of 15 fathoms.

II.

If the exterior Side takes up from 80 to 140 fathoms, it is to be divided into 5 equal parts; of which one is retained for the *Demi-Gorge*. The Flank changes according to the variety of the Sides. For example, if the exterior Side is of 80 fathoms, the Flank shall be of 16.

If of	90	the Flank of	17.
	100		18.
	105		19.
	110		20.
	115		21.
	120		22.
	125		23.
	130		24.
	135		25.
	140	the Flank of	25 Fathoms 3 Feet.

This being well understood, it will not be difficult to reduce it into Practice. Suppose the Pentagon following, of which the Side A B is 130 Fathoms, B C 124, C D 130, D E 113 Fathoms 3 Feet, E A 146 Fathoms, and that you design to Fortifie it.

1. Allow the fifth part of each exterior Side for the *Demi-Gorges*, as A F, B G, C I, C K, D L, D M, E N, E O, and A P.

2. Raise upon F G, H I, K L, M N, O P, Perpendiculars for the Flanks, in case you cannot allow them an Overture of 100 degrees; the Length of which must be proportionable to the Length of the Sides. For Example: The Flanks F G shall have 24 Fathoms, H I 22, K L 24, M N 20, E A 25 Fathoms and 3 Feet.

3. In drawing the Line of Defence, you will have the Faces at the same time.

4. The Base of the Rampart takes up 11 Fathoms, That of the Parapet 3. The Breadth of the Moat 20 Fathoms. The Covert way, and the Glacis, are made as is usual. See the Plate W. *Fig.* 40.

Observation.

The Flank is left after the *Holland*-manner; that is to say, without either *Orillon*, or hollow Tower, to avoid over-much Expence.

III.

If the exterior side be from 140, to 170 Fathoms, the Flanks are allowed the following Length;

If it be 145, allow the Flank 25 fathoms, 3 feet.
If 150, to the Flank 26 fathoms.
If 155, to the Flank 26 fathoms, 3 feet.
If 160, to the Flank 27 fathom.

IV.

The exterior Side surpassing the Length of 160 fathoms, to 280, is look'd upon then as if it had two sides; that is to say, that besides the Bastions which are placed upon the Angles there should be a Plat-form in the middle; as you see in *Fig.* 41, where the Side A B is 200 fathoms, and the Construction of it thus;

1. Divide the Side A B into two equal parts; as, A C, C B.

2. Divide either the Distance A C, or the other C B into five equal parts; to give one of them to the Demigorge; as, A D, E B, C F, C G.

3. Raise upon D G, F F, the Flanks of an Overture of 100 deg. the Length of which shall be the Demi-gorge.

4. From the Point C, draw the Capital, which takes up the Length of the entire Gorge; as, C H.

5. Join the Extremities of the Flanks, and the Point H, together, by a streight Line, to gain the Faces. See the Plate W, *Fig.* 41.

Observation.

These sorts of Bastions are perfectly well defended; for the Flanks of the neighbouring Bastions play backwards upon their Faces; besides that, almost all the Curtain serves them instead of a second Flank, and very much augments their Defence.

V.

The Exterior Side surpassing 280 Fathoms, two flat Bastions are placed there; holding this for a Maxim that the greatest Side ought to be 140 fathoms.

CHAP.

CHAP. XVII.

How to Fortifie an Acute Angle.

IF you find by chance an Acute Angle with the Circuit of a Place which is to be fortified, since it is impossible to repair this defect, because you are obliged to make use of the old Rampart; you are only to put upon this Angle a *Tenaille-Bastion*; which is thus erected:

1. Having made the Flanks, draw the Faces as the Line of Defence requires; but in regard they would be excessive long, and would form too acute a Point, that is corrected by putting 40 fathoms from the top of the Flank above the Face; as, A B, C D.

2. Join B D together by a right Line, and then divide that Line into two equal Parts, B E, E D; and from the middle of the same Line, let fall a Perpendicular, which has for its Length the third part of the same Lines; as, E F.

3. Draw the Points B D, in the Point F, by right Lines, and your Bastion is made. Oftentimes they erect little Ravelins before these sorts of Bastions: But to say the Truth, this Work is not worth any thing; nor is it ever to be made use of, but upon necessity. But you shall meet with it in some Places; as, at *Geneva*, and *Charlemont*. This small Ravelin must not be separated from the Bastion, but by a small Moat of five or six fathoms. Moreover, there is no necessity for its having Ramparts, but only a good Parapet, Cannon proof. There are several other Ways of fortifying an acute Angle, but which are of no more value than this. Therefore we must endeavour to avoid them; for notwithstanding all the care a Man can take to fortifie this Angle, it will be very defective. See the Plate W. *Fig.* 42.

CHAP.

CHAP. XVIII.

How to fortifie a Re-entring Angle.

THere are few irregular Places, of which the old Enclosure does not form a re-entring Angle, which is almost always secure, as being seen from several parts. But usually it is accompanied with one defect, that it almost always forms the two saliant Angles which are next it, no acute. 'Tis true, that if these saliant Angles were not so acute, your Firing-place would be very great, from a Work made upon the Re-entring Angle, to defend the Bastions that are in sight of it; nor is it always a Fault to have these re-entring Angles, which are thus fortified.

If the Angle be not very far sunk in, and very obtuse, as A, it is thus to be fortified;

Place on each Side the Angle great Demi-Gorges, as the Sides will permit it, and raise perpendicular Flanks, as large as you can.

Join their Extremities together, by a right Line; which you shall divide into two equal parts; and from the middle raise a Perpendicular, containing the Moiety of the said Line.

Draw the Extremities of the Flanks toward the Capital Line of that Perpendicular, and your re-entring Angle will be fortified. See Plate X. *Fig.* 43.

If the re-entring Angle be somewhat obtuse, or streight, in this Case, having taken good Demi-Gorges from every side of the Angle, the Flanks are there to be rais'd; the meeting of which, forms the Saliant Angle B; which is capable to defend the neighbouring Bastions. See Plate 10. *Fig.* 44.

CHAP.

CHAP. XIX.

Of the Artillery.

HAving given some account of Irregular Fortification, reserving to our selves another Time to speak more of it; we shall only observe what sort of Artillery they have in *France*. There is 1. The *Cannon*, which is call'd the Battering Piece. 2. The *Colveran*. 3. The *Falcon* 4. The *Saker*. 5. The *Petard*. 6. The *Small Petard*. The Battering Piece is 10 Feet long, The Bullet about six Inches Diameter, and weighs 33 pounds requiring two pounds of Powder at least, to charge it; and it carries directly forward 360 Fathoms. At the distance of 100 Fathoms, it pierces two Fathoms of clos'd Earth. If it be not well settled, it pierces two fathoms and a half; and if the Earth be poor, and hungry, it pierces four fathoms. You may discharge it eighty times in a day. The *Dutch* Cannon flings a Bullet of 48 pounds, 400 feet distance, and pierces a Rampart of good and well clos'd Earth 20 feet deep. A half Piece of Battery carries a Bullet of 24 pounds, at 300 feet distance, and enters twelve feet of good Earth. The *Falcon* carries a twelve pounder 200 feet off, and enters 7 feet into a good Parapet.

A *Small Petard* cannot break a double Gate well barr'd.

A *Great Petard*, fix'd to a weak Gate, usually makes no more than a Hole; and the greatest Execution it can produce, is to break the fore part of it.

There is nothing can stop the Execution of Mines, as they make them at present; nevertheless there must be a Proportion between the Petards, the Mines, &c. and the Powder.

Lastly, A Musquet carries 120 Fathoms, and if double charged 150, though it will kill a Man above 300 Paces. Discharg'd very near it will pierce two Planks two Fingers thick; but discharg'd at 50 Paces, it enters according to the substance of the Body it meets with. We shall insist no longer on these things at this time; intending to speak more amply of them in another Treatise, where we shall shew the manner how to attack a Place.

THE END.

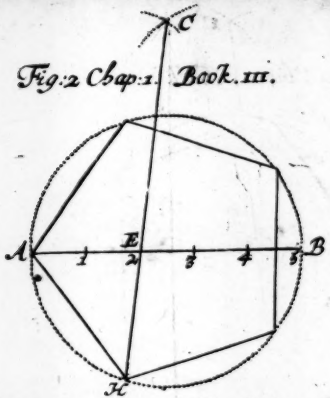


Fig: 2 Chap: 1 Book. III.

A Scale of 20 40 60 80 100 Fathoms.

A Draught & Square of Vaubane.

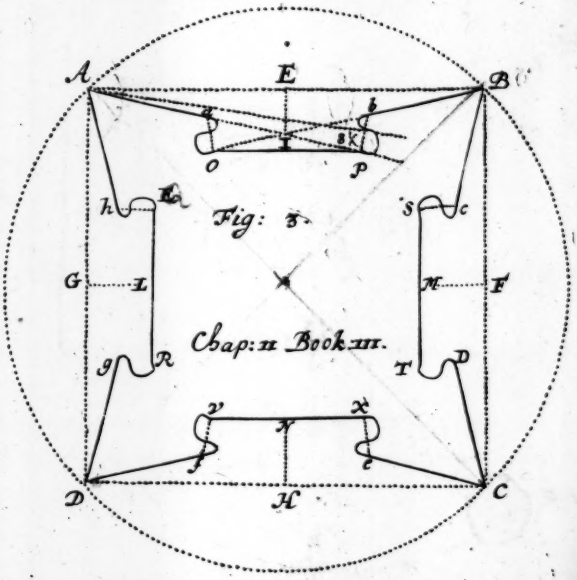


Fig: 3.

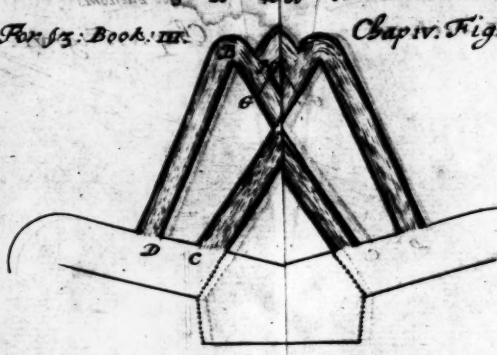
Chap: II Book. III.

A Scale for this Draught

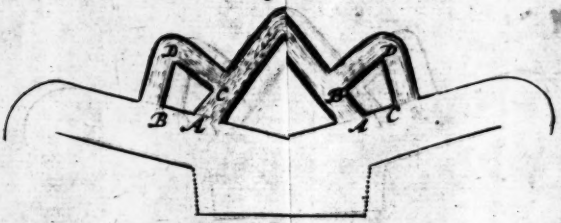
20 40 60 80 90 100 Fathoms.

The Plan of a Square together with an Horn Work before the Courtin

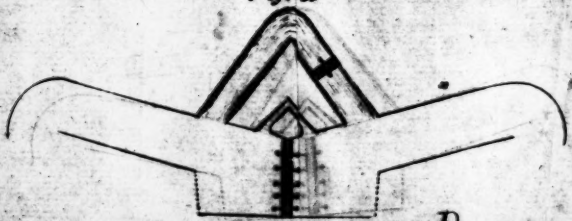
Fig. 4.



For. 12 Book III.
Chap. V.
Figr.



For. 14 Book III.
Chap. V.
Fig: VII



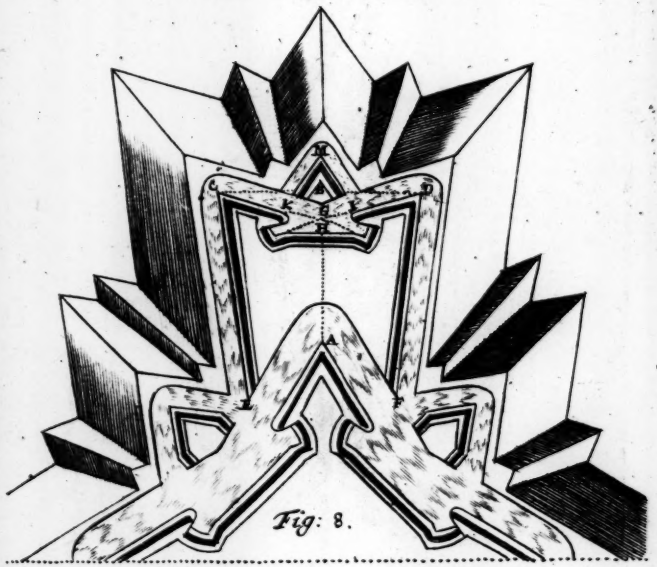


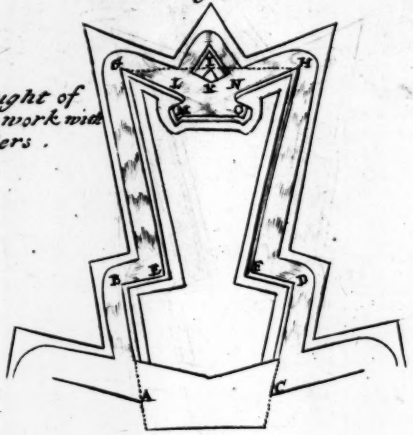
Fig: 8.

The Plan of a Horn Work before the Bastion of a Square.

A Scale of $\frac{1}{5}\ \frac{1}{10}\ \frac{1}{20}\ \frac{1}{40}\ \frac{1}{60}\ \frac{1}{80}\ \frac{1}{100}$ Fathoms.

Fig. 9.

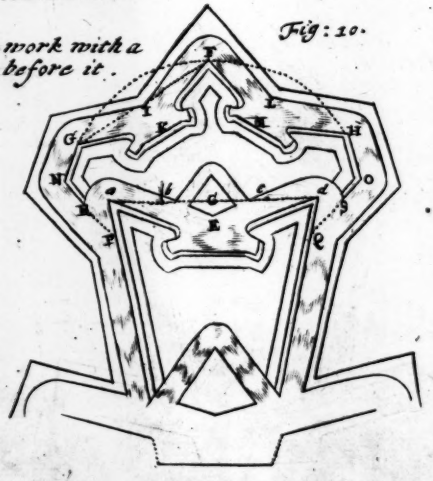
The Draught of a Horn-work with Shoulders.



CHAP: IX. Book. m.

a Horn-work with a Crown before it.

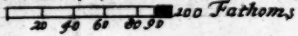
Fig: 10.



A Scale of 100 Fathoms or 600 Foot

Note a Fathom 13 6 Foot.

The Scale of this Plan



a Crown Work before the Bastion of a Square Vaubane

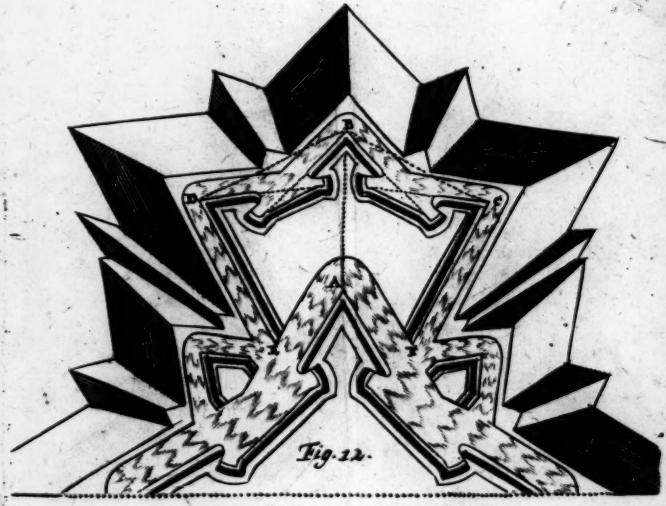


Fig. 12.

A Scale for this Plan.
Fathoms.
20 40 60 80 100
Fig: 13.
The Plan of a square work with a Counter scarp. a horn tarpard and Ravelins
Fig. 7.

A Scale for this Draught. 20 40 60 70 80 90 100 Fathoms

CHAP. XIII. BOOK III. CHAP. XIV. BOOK. III.

Fig: 15.

A Scale of 10 20 30 40 50 60 70 80 90 100 Fath.ᵗ to this Draught.

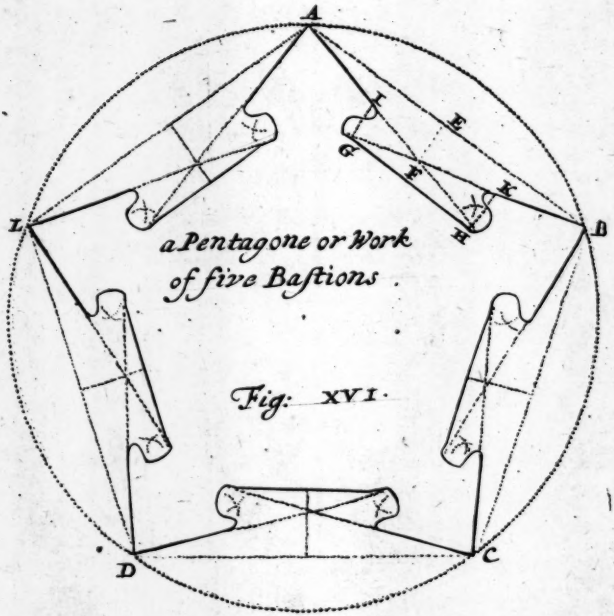


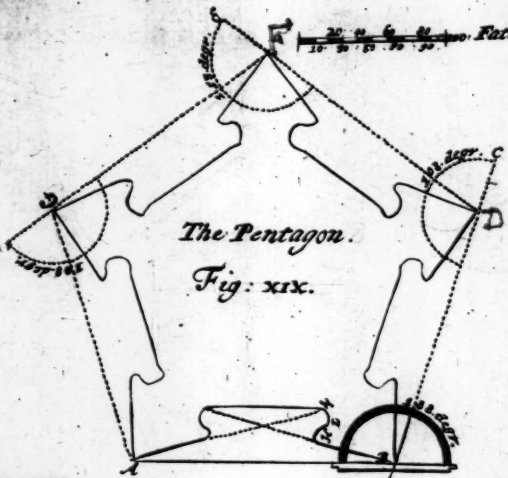
Fig: XVI.

Chap: XVI. Book. III.

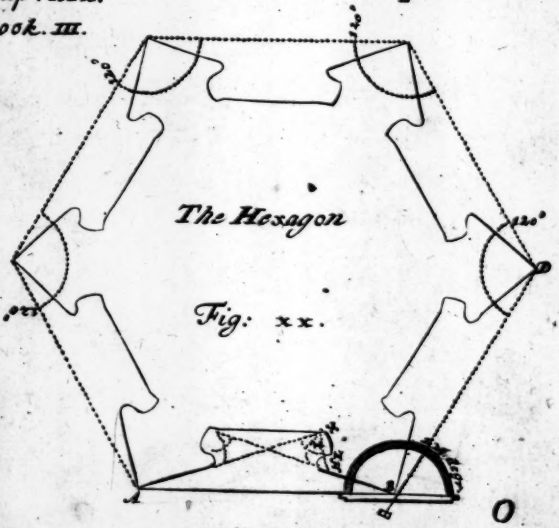
Scale for this plan 10 20 40 60 80 100 of Fathoms

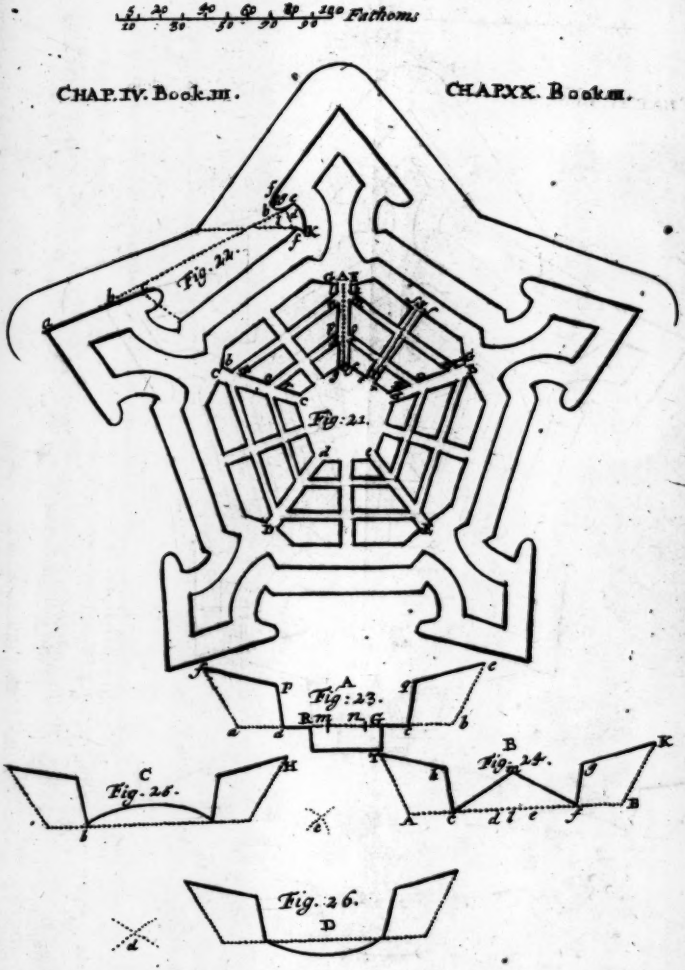
A Draught of a Pentagone or five sided Figure with Tenailles within the Ditch

Fig:16.



Chap: xix.
Book. iii.





These four Draughts or Plains of Courtines belong to CHAP. V. Book IV.

A Scale of 20 40 60 80 100 Fathoms.
20 30 50 70 90

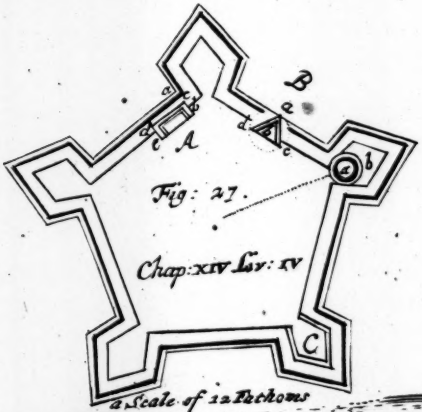


Fig: 27.

Chap: XIV Lib: IV

A Scale of 12 Fathoms

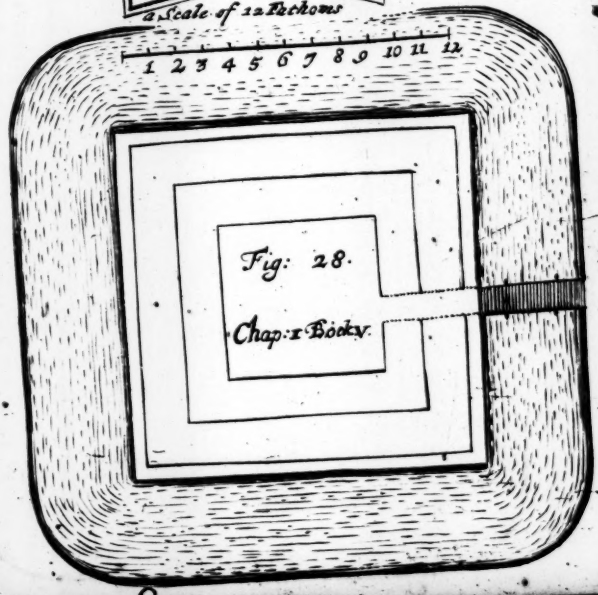
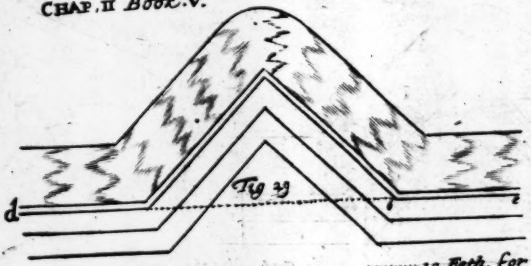


Fig: 28.

Chap: I Book V.

A Scale of 1 2 3 4 5 6 7 8 9 10 Fathoms

CHAP. II Book. V.



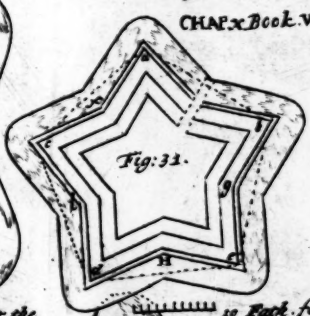
10 Fath. for the Star. Pentagon.

Fig: 30.

CHAP. III. Book V.

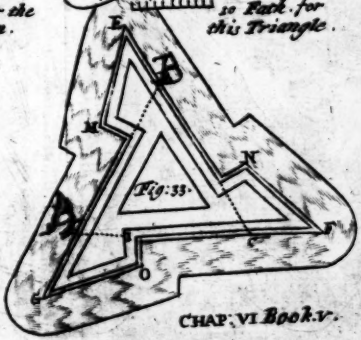
10 Fath. for the Hexagon.

CHAP. X Book. V.



10 Fath. for this Triangle.

CHAP. V. Book V.

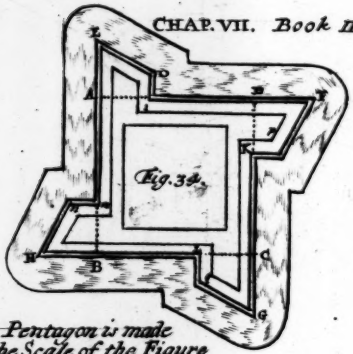


CHAP. VI Book. V.

A Scale of 12 Fathoms

A Scale of 10 Fathoms for a Square

CHAP. VII. *Book III.*

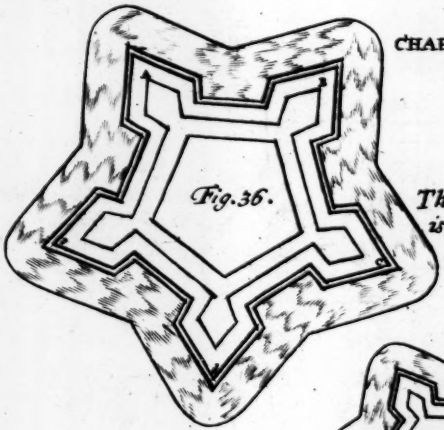


This Pentagon is made by the Scale of the Figure above Number 34.

CHAP. VIII. *Book IV.*

Fig. 35.

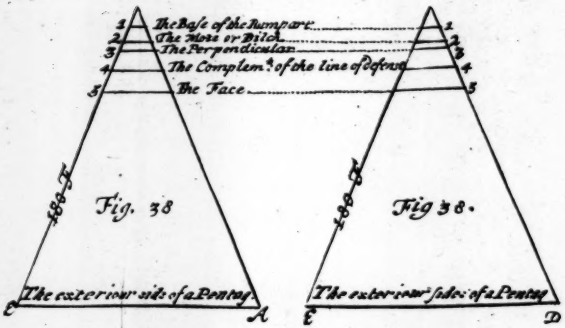
CHAP. IX. *Book V.*



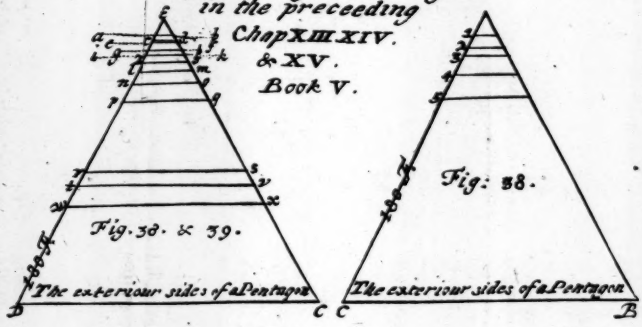
This demy-Hexagone is made by the Scale of Fig. 35.

CHAP X. Book V.

The Scale for these Triangles is in the preceeding page.



The figure of the Triangles of the irregular Pentagon in the preceeding Chap XIII XIV. & XV. Book V.



A Scale for these three Plan's

10 20 30 40 50 60 70 80 90 100 Fathoms.

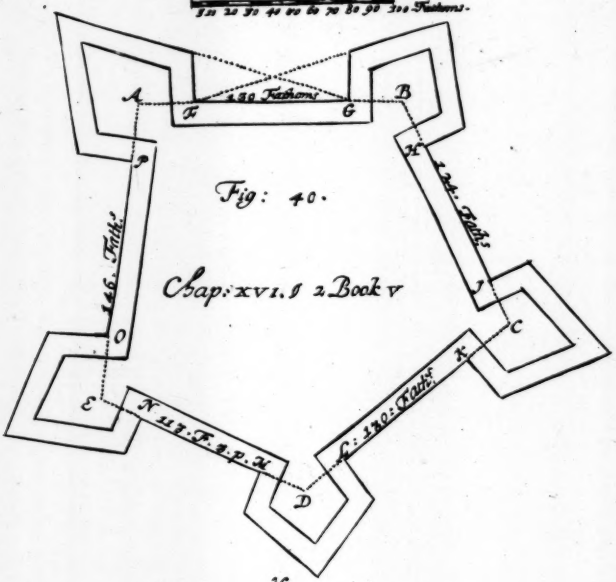


Fig: 40.

Chap: xvi. § 2 Book v

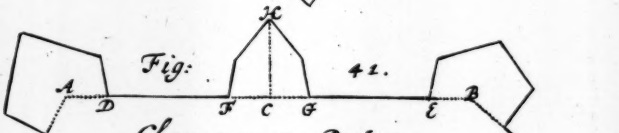
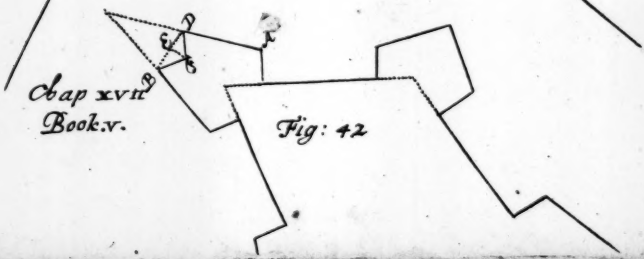


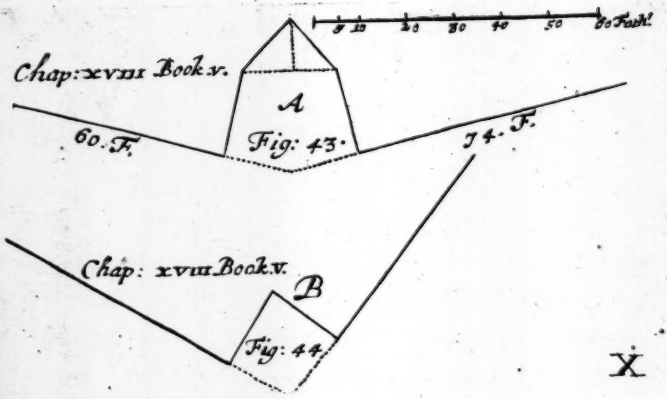
Fig: 41.

Chap. xvi. §. 4. Book: v.

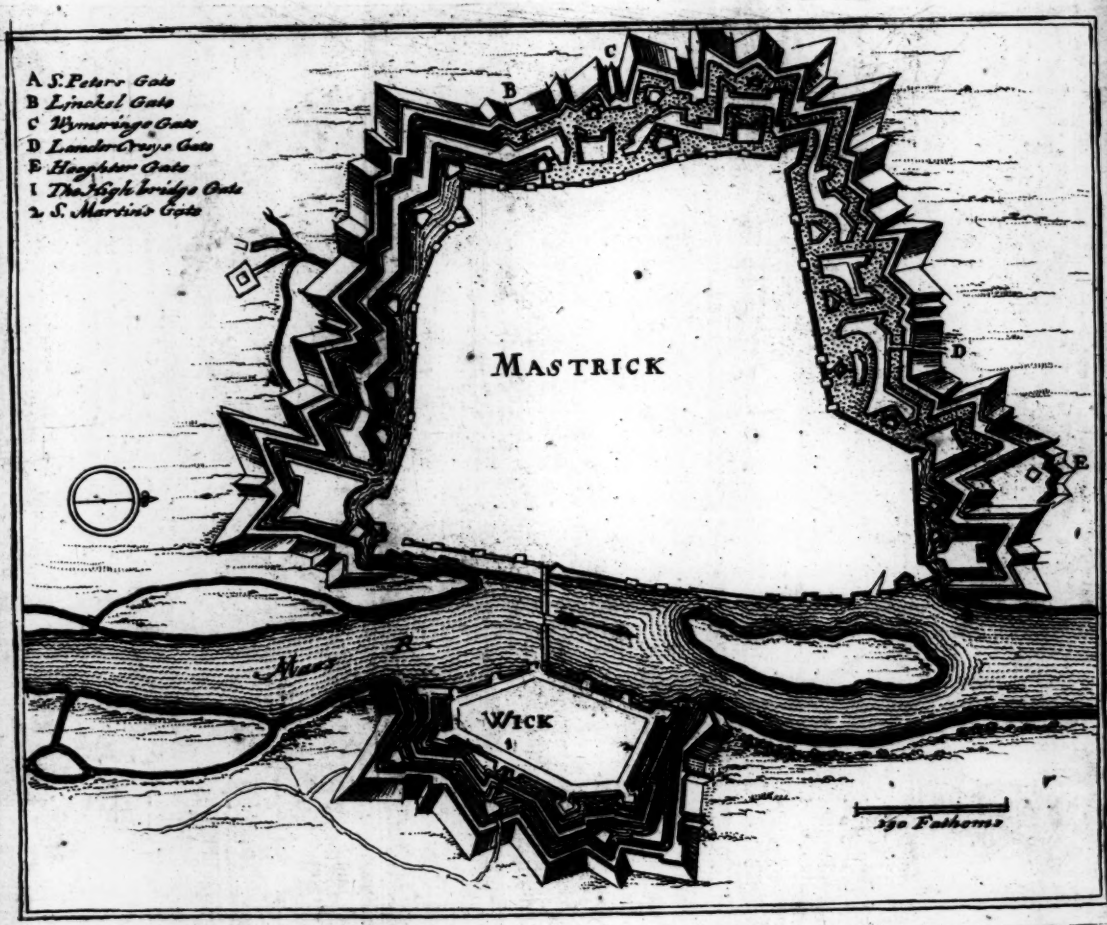


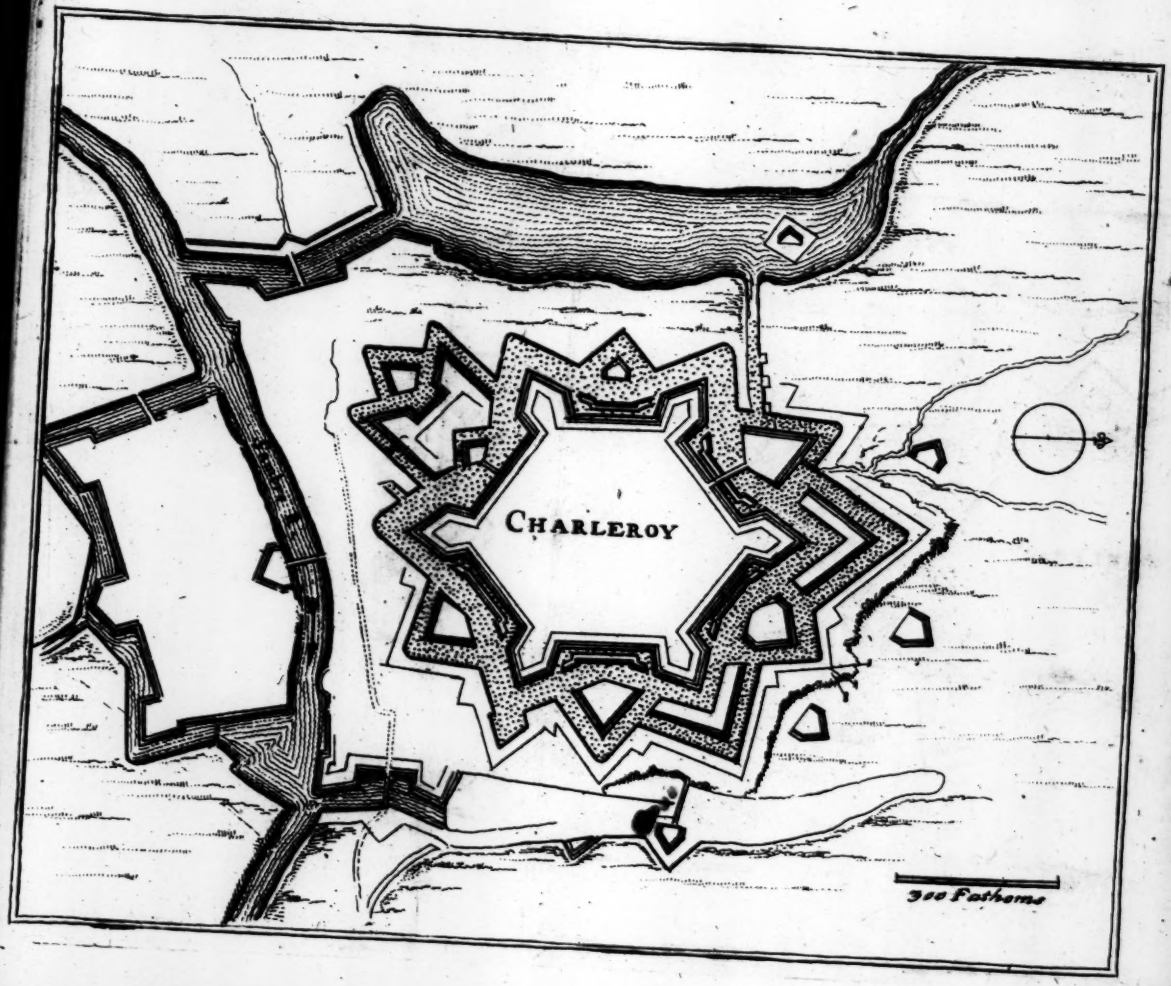
Chap xvii Book: v.

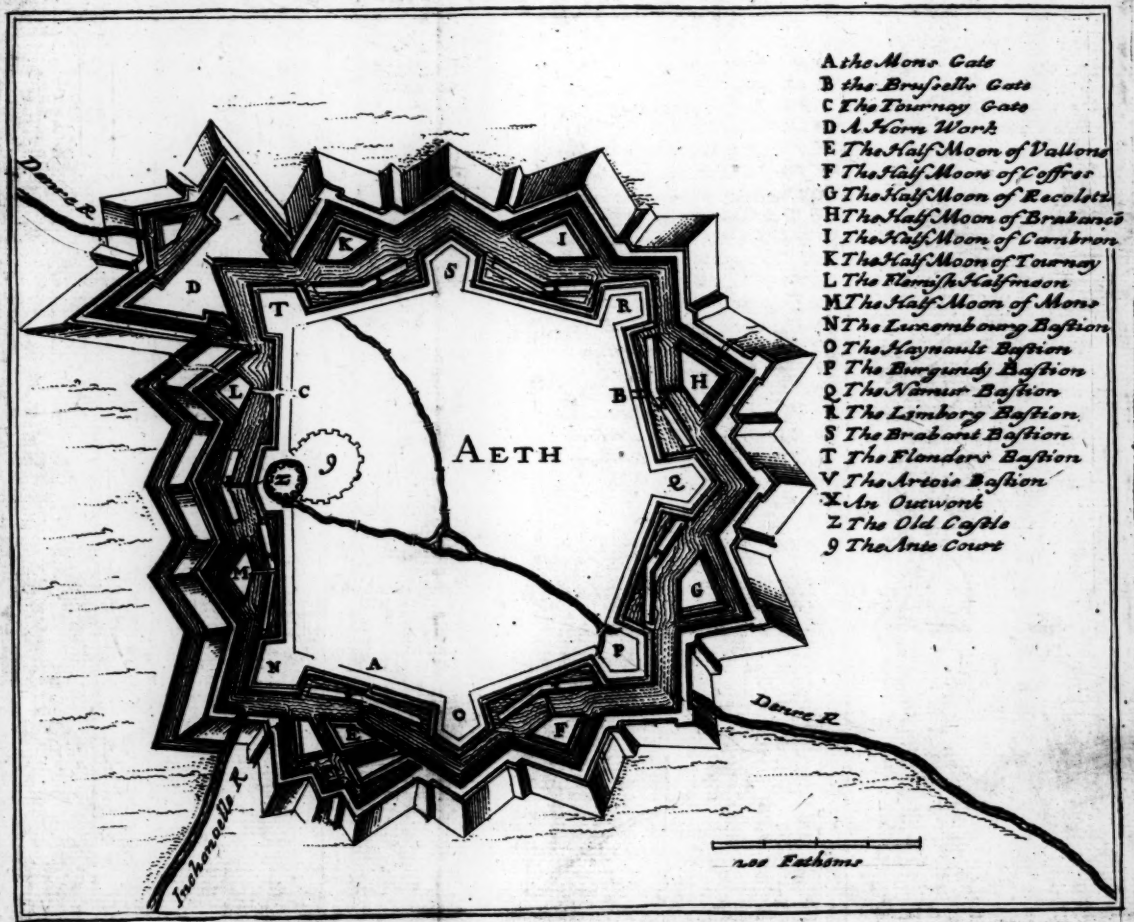
Fig: 42

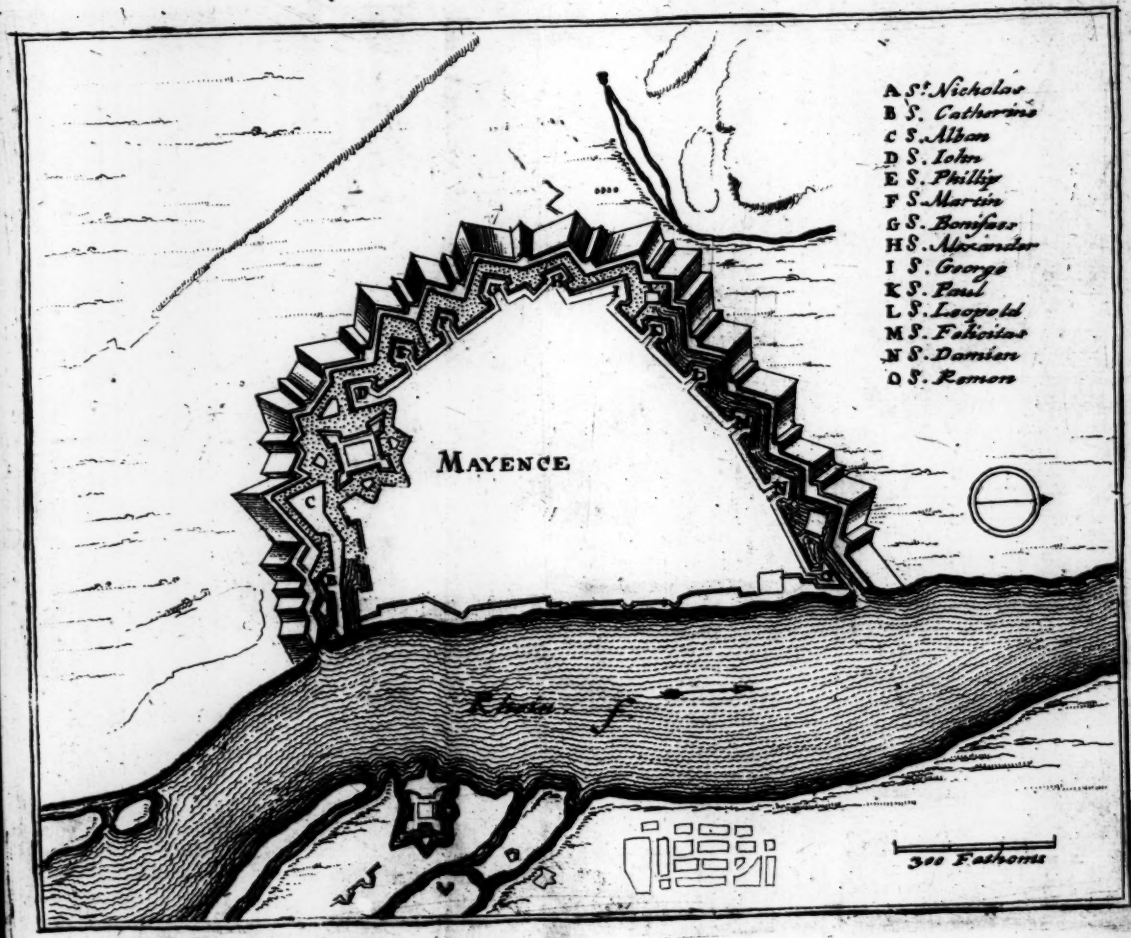

10 20 30 40 50 60 Fath!
Chap: xviii Book v.
A
60. F.
Fig: 43.
74. F.
Chap: xviii Book v.
B
Fig: 44.

X


A S. Peters Gate
B Linckel Gate
C Wymeringe Gate
D Lander Creys Gate
E Hoeghter Gate
1 The High bridge Gate
2 S. Martins Gate
MASTRICK
WICK
Mars R.
130 Fathoms


CHARLEROY
300 Fathoms


A the Mons Gate
B the Brussells Gate
C The Tournay Gate
D A Horn Work
E The Half Moon of Vallone
F The Half Moon of Coffres
G The Half Moon of Recoletz
H The Half Moon of Brabancō
I The Half Moon of Cambron
K The Half Moon of Tournay
L The Flemish Halfmoon
M The Half Moon of Mons
N The Luxembourg Bastion
O The Haynault Bastion
P The Burgundy Bastion
Q The Namur Bastion
R The Limborg Bastion
S The Brabant Bastion
T The Flanders Bastion
V The Artois Bastion
X An Outwonk
Z The Old Castle
9 The Ante Court
AETH
Denre R.
Inchonvelle R.
100 Fathoms


A St. Nicholas
B S. Catherine
C S. Alban
D S. John
E S. Phillip
F S. Martin
G S. Boniface
H S. Alexander
I S. George
K S. Paul
L S. Leopold
M S. Felicitas
N S. Damian
O S. Remon
MAYENCE
C
Rhenus fl.
300 Fathoms